THE

ELECTRICAL REVIEW.

VOL. XL. APRIL 2, 1897. No. 1,010.

CONTENTS:

	PAGE
Transmission of Power by Alternating Currents...	441
The Extensions at Worcester	443
Rotary Converters (*illustrated*)	444
The Cost of Energy on Electric Tramways	445
An Electric Yacht (*illustrated*)	445
High Voltage Lamps and Central Station Practice	447
A Two-Thousand Horse-Power Turbine (*illustrated*)	448
Measuring the Cable Currents Existing During a Conductor Resistance Test	449
The Incandescent Lamp Situation in America	450
Fraser's Boiler and Condenser (*illustrated*)	450
French Cable Laying and Repairing Steamer *Portena* (*illustrated*)	451
The Bradley Aluminium Patents (*illustrated*)	453
Correspondence:—Colwyn Bay Electric Lighting Scheme ...	454
Insulated Conduit	455
A Field for Electric Power	455
Cable Jointing	456
Dynamo Fields	456
Ethics of Modern Science	456
Business Notices, &c.	458
Electric Lighting Notes	459
Electric Traction and Motive Power Notes	460
Telegraph and Telephone Notes	461
Contracts Open and Closed	462
Notes	463
City Notes	465
Traffic Receipts	466
Share List of Electrical Companies	467
Proceedings of Societies:—	
The Institution of Electrical Engineers	468
The Physical Society	469
The Electric Lighting of Country Houses	470
Multiphase Induction Motors (*illustrated*) (*continued*)	472
The Transmission of Power to Long Distances by Alternating Currents of Electricity...	474
New Patents	476
Abstracts of Published Specifications	476

THE
UNIVERSAL ELECTRICAL DIRECTORY
(J. A. BERLY'S).

PRICE 6/- POST FREE.
The Leading Electrical Trades Directory and the Oldest Electrical Directory in the World.

1897 ISSUE NOW READY.

PRICE 6/- POST FREE.
Fully Revised and Thoroughly Reliable.
Contains a larger amount of Trade Matter than any other Electrical Directory.

H. ALABASTER, GATEHOUSE & CO.,
22, Paternoster Row, London, E.C.

THE ELECTRICAL REVIEW.

Published every FRIDAY, Price 4d.

The Oldest Weekly Electrical Paper. Established 1872.

TO BE OBTAINED BY ORDER FROM ANY NEWSAGENT IN TOWN OR COUNTRY.

OFFICE:—22, PATERNOSTER ROW, LONDON.

Telegraphic Address: "AGENKAY, LONDON." Code A B C. Telephone No. 6,933.

ALL Letters should be addressed to the Proprietors, H. Alabaster, Gatehouse & Co.

ADVERTISEMENT RATES ON APPLICATION.

The "Electrical Review" is the recognised medium of the Electrical Trades.

SUBSCRIPTION RATES.—In *Great Britain*, Post Free per Year, 19s. 6d. To *all other countries*, per Year, £1 4s.

BINDING.—Subscribers' numbers bound, including case, for 4s. each volume.

CASES.—Cloth Cases for Binding can be had, price 2s. 6d. each.

READING CASES, to hold from One to Twenty-six Numbers until the Volume is complete for Binding, can now be had from the Publishers, Price 6s. or Free by Post (in Great Britain), 6s. 6d.

FOREIGN AGENTS.—New York: D. VAN NOSTRAND, 23, Murray Street. *Paris:* VEUVE J. BOYVEAU, 22, Rue de la Banque. *Berlin* ASHER & Co., 5, Unter den Linden.

Cheques and Postal Orders (on Chief Office, London) to be made payable to Mr. H. ALABASTER, 22, Paternoster Row, E.C.

TRANSMISSION OF POWER BY ALTERNATING CURRENTS.

THE Society of Arts paper on this subject, which we are reproducing may be taken as a summary of the present position in the progress of alternating current machinery, and the best practice in transmitting power by its means. There is but little novelty in the machinery described, hence the paper does not mark any new advance; but it is interesting to engineers, inasmuch as it reveals the fact that some serious difficulties still attend the working of alternating current transmission plants.

Alternators are subjected to constant vibrations. In a single phase alternator the vibrations have the same frequency as the current, and can be felt and heard; the drag on the coils is intermittent. In a two-phase machine with mixed armature coils, the vibrations are much reduced, for the one set of coils are subjected to a maximum drag at the instant the others are out of it. Three-phase alternators also have less mechanical vibrations than those of the single phase type. These are additional advantages in polyphase machines with mixed coils in the armature, to that mentioned by the author, namely, the reduced armature reactions.

The whole argument in favour of using alternating systems for transmitting power is based on the ease with which the pressures can be altered and adjusted; that is, after all, the corner stone of all alternating current systems, with perhaps the additional advantage of the absence of commutators on the motors and generators. Engineering skill has, however, so much improved armature and commutator construction, that the absence, or presence of, commutators, is not of such great importance as it was 12 or 13 years ago, when alternating current machinery was first introduced. Even in electric lighting, the whole foundation upon which the arguments in favour of alternating currents are based has shifted amazingly.

Hence we are not surprised at the position taken up by the chairman (Mr. Alexander Siemens) at the discussion on the paper. His firm has installed some large and important alternating power plants, and yet it is his deliberate opinion that continuous currents are best for transmission of power!

The old beliefs and arguments no longer hold, and of recent practice we have had no adequate discussion of the *pros* and *cons* on the question, Alternating *v.* Continuous Current Systems; it is therefore well that Mr. Siemens raised the point, and so deliberately expressed his own convictions.

There can be no doubt that in transmission of power plants simplicity is of utmost importance; the work is heavy

and continuous, and the plant is often placed in mines, shipyards and factories, without the loving care usually bestowed on electric lighting plants by numerous tenders.

It is very easily shown that there are considerable advantages in using a stationary transformer to raise or lower electric pressures in a long distance transmission installation. At same time, several complications are quite as easily seen. The chief one referred to in the paper, *i.e.*, the low power factor, is a very serious one in practice, for it wipes out from 30 to 50 per cent. of the saving effected by using the alternating current. The alternating current is first adopted to enable high pressures to be used, this with a view to save copper or loss of energy in transmission, or both; then the power factor is found to be something between 50 and 70 per cent. only, so that for equal pressures the same transmission plant would transmit more energy as continuous current up to the extent indicated. To this must be added the introduction of transformers and the question of motors. There is some energy lost in transformers, and their first cost also reduces the saving due to the use of high pressure.

Then we come to the motor, about which Mr. Esson does not say much, beyond referring to the low power factor.

The synchronous single-phase motor, compared with a continuous current motor, may be represented as complication *versus* simplicity. In the former we find a starting apparatus more or less cumbrous and complex, together with an exciter with commutator, and of course a transformer; in the latter we have only the one machine.

The problems in using single-phase currents are claimed to be solved by several motors of the induction type, but many competent electrical engineers express doubt on that point. They certainly dispense with the commutator and exciter, but have other weak points.

We agree with the author that the induction motor, whether single phase or polyphase, is, taken all round, the best, but we have not yet seen the single phase induction motor entirely free from starting difficulties.

It is to the three or two-phase systems we must look for the best alternating transmission of power plant. There is not any difficulty with these motors, only they are not, in larger sizes at any rate, so simple as one would suppose, for sliding contacts and resistances come in to render them somewhat complicated.

Of the two systems the author prefers, for several reasons, the two-phase methods, principally because unequal loading of the different phases has no evil results on the two-phase, while it has some in three-phase transmission; this, however, is not quite a good argument in transmission of power work, for the different phases are always equally loaded when working motors only. The two-phase motor is simpler than the three-phase when contact rings and resistances are required.

Turning to the figures and tables given by the author, they may be accepted, as Mr. Mordey says, like the multiplication table; but they prove more than the deductions drawn from them in the paper under discussion. In the example taken to show costs, the pressure of 1,000 volts comes out cheaper than higher pressures up to one mile distance; but a continuous current plant would come out much cheaper and more economical, for the £250 could be spent on more copper in the line, the power factor would be unity, and no one at this day would consider there were any serious difficulties in working continuous current motors at high pressure, say 700 volts. The engineer has not only to ascertain what is the cheapest alternating method, but also whether continuous current is not better and cheaper under the circumstances.

The single bobbin alternator has, according to the author, a considerable magnetic leakage. No doubt it has when the poles interlace, as in the machine referred to in the paper. The alternate poles are of opposite polarity, and are laid close together, so the leakage must be considerable, but in other single bobbin alternators such as Mordey's, where the adjacent poles are similar on any one side, the leakage is extremely small under any load. The difference in leakage between the two designs is entirely due to the different arrangement of poles, and not to the coil exciting them being some distance from its work.

In large powers to be distributed at a distance over one mile or so from the generator, the polyphase system is worth considering, but under that distance, and for such powers as are required in the cases of mines, factories, shipyards, &c., which have to be dealt with in this country, continuous currents are better, simpler, and cheaper for transmitting and distributing the power.

In great schemes like Niagara the conditions are altogether different; alternating systems are the only ones to be considered in such long distances and large powers.

Long ago we advocated the adoption of a standard frequency, as the different frequencies in vogue throw unnecessary difficulties in the way of the manufacturer of motors, arc lamps, &c. A frequency of 60 is high enough for any purpose, and low enough for electric lighting; but a frequency of 20 is better for motors, and this points to the use of separate circuits in alternating systems for light and power. The frequency difficulty is another complication which does not arise in continuous current working.

The paper, no doubt, is directed principally to long distance working, but we believe there is a large future for electrical distribution of power in manufacturing towns, and the discussion of power transmission schemes might profitably include that part of the problem.

If the polyphase motor is all that is claimed for it, there is one application in which we should have thought it would have displaced the continuous current motor, and that is in tramway car propulsion. It seems odd that in some places they use three phases to transmit the power, and then convert it into continuous current for use on the cars! Facts like these make engineers inclined to take these assertions about starting torque, efficiency, and so on, *cum grano salis*.

It is only fair to those who took part in the meagre discussion to add that in the reading, quite one-third of the paper had to be omitted. There were, however, many points open to comment, and in the paper there is material enough for anybody knowing something of the subject to bring about a really valuable discussion through the medium of our correspondence columns. The names of the men who could tackle the matter readily occur to one's mind, and as we have reason to know that Mr. Esson is inclined not only to court but to invite criticism, we have set the ball rolling, and cordially invite our readers to keep it going by "free kicks" until the goal at which the author is aiming is reached.

THE EXTENSIONS AT WORCESTER.

Day-Plant, Switchboard, Sliding Scale, and no Meter Rent.

A very interesting document appeared about a month ago in the shape of an abstract of the electric lighting accounts for last year of the City of Worcester supply, and a report by Mr. Ruthven Murray, the city electrical engineer. Taking the accounts first, we find that the total capacity of plant installed is 500 kilowatts, comprising four alternators of 125 kilowatts each. Three of these units can be driven by steam or water-power, and one by water-power only. The sales during 1896 were as follows:—

Motor driving pumps at water works	124,212 units at 1·35d.
Public lighting	42,565 units at 2·80d.
Private supply, day load	10,569 units at 1·75d.
Private supply, lighting	156,298 units at 4·58d.
Giving a total of	333,644 units at 3·068d.

This represents a revenue of £4,265, and meter rents, fees, &c., a sum of £492.

With a total of 21,958 three-watt lamps connected, the maximum load was 310 kilowatts; 10·91 units being sold per lamp average.

The capital expenditure entailed may be summarised as follows:

Site	£5,782
Buildings	20,763
Machinery, mains and transformers ...	32,166
Meters	1,479
Instruments	264
Stores and other expenses	862
The actual total being	£60,718

or equal to £104 per kilowatt installed.

Excluding interest and sinking fund charges, the works' costs are 1·488d. per unit sold (a decrease of rather more than ¾d. on the previous year's figures), and total costs, 2·269d. (representing practically the same decrease).

We may now turn to Mr. Ruthven Murray's report to note the changes and suggestions he makes. Firstly, as it is notorious that the water power scheme has been at best but a partial success, it is natural that he should deal with methods of reducing the figure for coal, 1·064d. per unit generated by steam and sold. The figure, so far attained, has been brought about by improving the load factor on the engines and by adding condensing plant, as well as assisted by a reduction in the price paid for coal. But with large engines and variable water power a record cannot be expected, and we think that credit is due to Mr. Ruthven Murray for having done so well. To do better, it is proposed to add a 100 I.H.P. high speed engine to drive the existing alternator at present driven solely by water power. This would take it up to half-power, and with water and steam together, it could work up to full load. The addition of the engine would provide a day or light load plant, and we can well believe that a very material saving will be effected thereby. Although an unusual arrangement, there is much to be said for a large alternator coupled to a smaller engine for this special use, as the fly-wheel action will be considerable, and the drop in armature coils small. There will be then very little trouble in regulating, and a steady pressure should be maintained without any special care or attention being required. This is a matter that is too frequently overlooked, although of very great importance for light load running, as the electrician on duty, or charge engineer, should be more or less free to look after the overhauling of the plant in readiness for heavy load, and attend to men engaged on any repairs that may be in progress. The great mistake made in laying down day plants has been in selecting units that are much too small. Thus 25-kilowatt sets have frequently been installed, and there are some stations where the ridiculously toy plant of 10 kilowatts is to be found. No wonder that in the course of a year or two the "day plant" is thrown out and offered for sale as "inadequate to meet the demand on the works." At Worcester, it may be urged, the engineer is going in for a set that is equally ridiculous as being too large, and therefore for the purpose in view inefficient. This argument would have some weight were it the case that the major portion of the losses accrue in the engine room, but when it is remembered that radiation and stand-by losses are by far those of most importance, and that they will not be materially affected by the size of engine, within reasonable limits, run on light loads, it is evident that good regulation and the ability to cope with a sudden increase of 10 or 20 kilowatts of motor load, or lamps turned on in the event of fog or storm, are of more real advantage to the station engineer than a per cent. or two on engine or alternator. In our opinion, the smallest unit that is of any real service is about 40 kilowatts, and this corresponds to what has been found the best in direct current stations, where one frequently meets with 80 H.P. units for light loads, 120 H.P. for medium, and 300 H.P. sets for the serious work of a winter evening.

It is proposed to increase the plant at Worcester by the addition of a 300-kilowatt 500-H.P. engine direct-coupled set. This seems a size that is much in favour, and for very good reasons, as it is large enough for good efficiency, and yet not so large as to be unwieldy. But surely one such unit is of little use. Common sense dictates that the "spare" in a station should be equal to the largest set run, or equivalent to it in output. From the report before us, we judge that the equivalent spare is taken as three of the existing 125 kw. sets. Sundry small additions, which we need not here specify, are put forward for consideration, but it is worth noticing that the existing switchboard is spoken of in anything but satisfactory terms, and the hope is expressed that this may be replaced by new switch gear of the best possible design. Now, it is a curious thing, but a good omen, that there are only one or two forms of switches that have proved really satisfactory to those who have to use and be responsible for them, and the use they are put to. These are the plug type, in which everything is most carefully insulated and protected, and the lever type, in which the same results are arrived at in a different way. Our readers will recognise that to the first class belong the Fowler, Crompton, and Manchester Edison-Swan patterns, and in the second category the most prominent example is the design adopted by Ferranti. Very few modern stations are satisfied with anything less efficient, substantial, and safe, and it is a matter for congratulation that at Worcester the engineer has the courage of his opinions, and asks for something as good as his neighbours are using.

Notwithstanding the improved working, there was a loss of £1,616 on the supply last year at Worcester, after, of course, allowing for all the claims that have to be met by a municipal supply. Mr. Ruthven Murray has set himself the task of locating the weak points, and knowing where these occur, makes proposals to deal with them. We are not surprised to find that he attributes the deficit neither to the supply to the waterworks motors nor to public lighting—both of which are long-hour consumers—but to the inadequate charge made for general private supply, the consumption on which is small considering the power demanded. In other words, the whole loss is alleged to have been incurred upon the private supply by reason of the length of hours of burning not being sufficient to cover the fixed standing charges with which the undertaking is necessarily burdened. It is pointed out that a uniform charge of 5d. per unit is inequitable, and does not encourage profitable business, since this rate is too low to charge those consumers who use their supply only a short time each day, and upon whom a loss is thereby incurred, while it is too high for those who might use it for a long period daily, and consequently yield a profit.

The natural outcome of such facts is the suggested adoption of the sliding scale, based upon a knowledge of individual demands. The alternative, or Hopkinson principle (as the sliding scale is the Wright principle) of charging directly a sum per lamp,* to cover its own share of the fixed charges, and then to make a low price per unit meet the cost of supplying those units which are actually taken, and are relatively of less importance, is considered too drastic a

* Dr. Hopkinson, at Manchester, took lamps *fixed*, not lamps actually *demanded*. The latter is a modification which has been rendered possible since the "demand indicator" has become an accomplished fact. The old Liverpool scale, subsequently adopted by the House-to-House Company, was a true sliding scale based on lamps *fixed*. The Hastings (present) rate of charge of 1s. per lamp *demanded* per quarter, and a uniform charge for energy consumed, bears the same relation to the Hopkinson system as the Wright system does to the old Liverpool scale. In the Hastings and Wright systems the current is measured, and is taken as the "demand," whereas in the original Hopkinson and Liverpool scales, the lamps fixed were considered to be equivalent to the demand. This point is often overlooked by writers on the question of charging for electricity energy.

D

measure to apply to the short hour consumers at Worcester. The Wright system is slowly but surely making its way all over the country,* and "demand indicators" are used in addition in several instances where the sliding scale is not that devised by Mr. Arthur Wright.

The scale proposed for Worcester is:—

6d. per unit for the first hour's daily average use.

2½d. per unit for all consumed in excess of this amount.

The maximum demand to be taken monthly, and rebate allowed on the half-year's maximum demand.

The result of this scale is to give the following average prices:—

Average hours per day used.	Price per unit.	Estimated cost (average) per unit.	Profit or loss per unit.
1	6d.	6·95	− 0·95d.
2	4½d.	3·77	+ 0·48d.
3	3⅔d.	2·65	+ 1·01d.
4	3⅜d.	2·11	+ 1·26d.
5	3⅕d.	1·79	+ 1·41d.
6	3 1/12d.	1·57	+ 1·51d.
7	3d.	1·42	+ 1·58d.
8	2 2/10d.	1·30	+ 1·60d.
9	2 1/12d.	1·21	+ 1·70d.

As in all scales so far found practicable, the price per unit for one hour's consumption does not pay, but falls short of the total cost of being ready to supply and generating. As the operation of the system would be to make it worth while for consumers to increase their period of lighting,† we think that Mr. Ruthven Murray has made out a good case for his recommendation, and it certainly favours the consumer.

At Brighton the first hour is charged at 7d.; at Shoreditch and Hammersmith, although 6d. is the first hour price, the reduced price is as much as 4d., two-thirds of the initial; at Islington 7d. is still charged for the first two hours, and in other towns 8d. is taken to start with. Thus 6d. for the first hour only, and 2½d. all after, is very low, and makes so much difference to the consumer, that the Worcester works should benefit, as they deserve to do.

To still further obtain the good grace of the consumer of electricity, Mr. Ruthven Murray proposes to:—

(*a*) Give away one 8-C.P. or one 16-C.P. incandescent lamp for every 50 units of energy taken.

(*b*) Abolish meter rents in case of all consumers who use their demand for, or over, an average of 365 hours per annum, *i.e.*, one hour daily.

(*c*) Consider favourably the offers made by intermediary companies on the basis of (so-called) free wiring.

Free wiring, free lamps, no meter rents, and electricity at an average price well under 6d. per unit, show that electricity supply in the City of Worcester is progressing rapidly. In London, unfortunately, consumers are not yet so favoured. Free wiring is being attempted, and the Vestry of St. Pancras have abolished meter rents, but 6d. a unit as an all-round price is regarded as a boon where 7d. and 8d. is still paid for 90 per cent. of the energy consumed. We believe the Hampstead Vestry allow a discount based on consumption, but should not be surprised to find Mr. Cottam advocating a change to the sliding scale, and we are waiting to hear of a similar proposal from Mr. Baynes. When the two local authorities whom these gentlemen serve fall into line with the other three who have already accepted the principle, then the companies must follow, and a factor in the change can truly be said to be such reports from provincial cities and towns as we have briefly dealt with.

* The system is in use in Bournemouth, Brighton, Blackburn, Blackpool, Bolton, Cardiff, Cheltenham, Coventry, Glasgow, Hammersmith, Hove, Hull, Islington, Kingston, Northampton, Oldham, Preston, Shoreditch, Southport, South Shields, Stafford, &c.

† To effect this it is requisite that the reduced price should be sensibly lower than the initial price, otherwise sufficient mental inducement is not given consumers to benefit themselves by rebate price, and directly by doing so to do exactly what the supply station engineer wishes them. If the difference be only 1d. or 2d. per unit, the result of lengthened consumption for a given demand has so little effect on the average price, that in practice the theoretical benefits held out are not realised.

ROTARY CONVERTERS.

There is an interesting article in the *American Electrician* for February, 1897, by Mr. E. J. Berg, in which he gives an account of rotary converters.

Although rotary converters are of great use in the distribution of electrical energy, they do not seem to have met with their share of attention in technical journals.

When electrical energy is transmitted by means of alternating currents, either at high or low voltages, subsidiary machines have to be used to effect its distribution in the most advantageous manner. If the tension in the mains is high, transformers are, in the first instance, employed to bring the voltage sufficiently low. If, further, continuous current is required by a number of consumers, some device must be employed for converting the supply from alternating to direct current. This conversion may be effected either by using an alternating current motor mechanically geared to a direct current machine, or, more simply still, by means of a rotary converter.

A rotary converter, Mr. Berg points out, is simply a continuous current generator supplied with two or more collecting rings connected to suitable points of the continuous current winding. It is not used for the transformation of E.M.Fs. and currents after the manner of a stationary transformer, but merely converts alternating into continuous currents, and each type of converter has its definite ratio between its alternating (input), and steady (output) voltage.

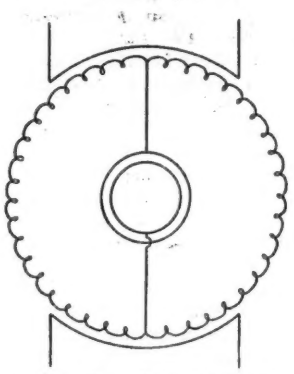


Fig. 1.—Two-Pole Simple Alternating-Current Rotary Converter.

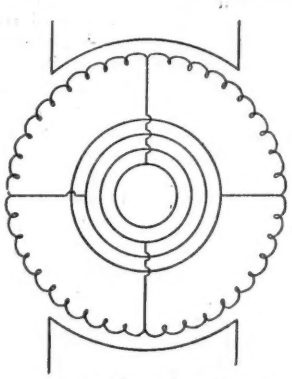


Fig. 2.—Two-Pole, Two-Phased Rotary Converter.

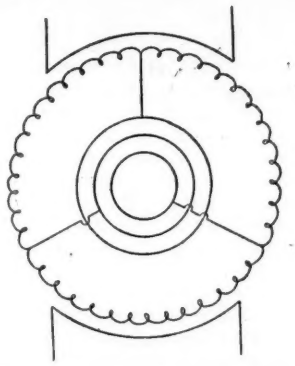


Fig. 3.—Two-Pole, Three-Phased Rotary Converter.

Assuming that the impressed potential difference wave is a sine function of the time the E.M.F. of the direct current of a single, or a two-phased, rotary converter is $\sqrt{2}$ times the R.M.S. value of the impressed P.D. In a three-phased converter the ratio of the direct to the alternating voltage is $\frac{2\sqrt{2}}{\sqrt{3}}$.

In consequence of this definite ratio which exists between the alternating and direct E.M.Fs., a rotary converter cannot be directly connected to high tension mains, but must be coupled to a step-down transformer. Also the secondary E.M.F. of the transformer should be 71 per cent. of the desired direct current voltage if the converter is single or two-phased, and 62 per cent. if three-phased.

Figs. 1, 2, and 3, taken from Mr. Berg's paper, show diagrammatically the collecting rings and the connections in

the cases of a two-pole generator connected as a single-phase, two-phase, and three-phase converter respectively.

If the continuous current generator is of multipolar design and series-wound, the connections are equally simple, but if the machine is multiple-wound connections to the collecting rings are made by regarding each pair of poles as a separate machine.

The efficiencies of polyphased rotary converters is very high, owing to the fact that heating losses are less than in a continuous current generator of the same capacity. This is due to the fact that the supply current is in opposition to the current generated in the converter itself. For the same reason the armature reaction is small and commutation difficulties are diminished. In a single-phase rotary converter, however, the reverse is the case.

It follows that a rotary converter is usually preferable to an alternating current motor attached to a direct current generator. There are, however, cases in which a synchronous motor is better, since it is not wise to use commutating machines for very high speeds.

A rotary converter is a hybrid between a synchronous motor and a direct current generator, and is susceptible of the same variations in design as these two machines. The excitation, which is produced in the same way as that of a direct current machine may be either simply shunt, or a combination of shunt and series, or it may have no excitation whatever.

The author of the paper quoted above states that the shunt type is chiefly adapted to lighting purposes, whereas the compound type is more especially suitable where continuous current has to be supplied for motive purposes.

A noteworthy point is that a rotary converter with shunt and series excitation can be made to have any desired power factor. The field is strongly excited and the tendency of the converter itself will be to make the generator current lead before the E.M.F., and, consequently, reactance between generator and converter, instead of being a source of trouble, is actually necessary for efficient working and for the automatic control of the voltage. On this account we cannot encourage the adoption of converters too much. Instead of tending to increase wattless currents in alternating current mains they have the reverse effect, which should cause them to find favour with all those who have to do with the regulation of the pressure at an electric lighting station.

One of the objections to the erection of an alternating current supply station is the difficulty of obtaining continuous current when required. The difficulty is most easily and economically overcome by means of a rotary converter.

THE COST OF ENERGY ON ELECTRIC TRAMWAYS.

When every different tramway system has different types and sizes of car it seems rather a hopeless task to attempt any sort of a comparison between the lines in regard to energy used per car mile. And yet there is no other standard that can be utilised in any way, and one is therefore obliged to take refuge in the universal car mile unit, comforted by the thought that after all it may not be very far out owing to the way in which loads average themselves, especially on large systems.

Mr. C. H. Davis is, therefore, somewhat of a benefactor to tramway engineers, in discussing this subject as he does in the *Engineering Magazine*, under the title of "Comparative Economy in Electric Railway Operation"; it must, however, at the outset be stated that the author aims more especially at one particular point rather than a detailed examination of all the outgoings in a power house. This special point consists of a proof of the very important fact that coal economy is by no means of such great consideration as a saving in labour and other items. That is, the employment of highly efficient and economical but expensive steam engines does not practically effect so great a saving as might follow from spending an equivalent amount of extra capital outlay upon track or rolling stock. Of course it has for some time past been well known by electricity works engineers in this country that the coal bill is by no means the largest part of the total manufacturing costs per unit; as a matter of fact the average amount would not reach so much as 30 per cent. of the costs in established power houses. There is, however, perhaps a danger of losing sight of this fact in regard to electric traction work, simply because the opportunity arises to build new stations and equip them with everything of the best, though without carefully going into all the conditions likely to rule the work.

Mr. Davis calculates that the average cost per car mile of operating electric lines may be assumed at about 13 cents; of this, 5·5 cents are spent on car labour, 3·5 on track and line, 2·5 on cars, and 1·5 on power. The last item is, therefore, only 11·5 per cent. of the whole, and since the cost of fuel is usually not more than 30 per cent. of the power house expenses (or say 50 per cent. to give ample margin), the coal bill is only 5·75 per cent. of the total expenses per car mile. Now any good ordinary high pressure single expansion engine will give enough energy per car mile for 15 lbs. of coal, which amount the use of a compound condensing Corliss engine will reduce to say 8 lbs., so that this saving of 46 per cent. in fuel only gives a saving in the entire expenses per car mile of 2·6 per cent. It obviously therefore requires a good deal of consideration as to whether this small saving is worth the greatly increased capital outlay upon more efficient and economical engines, at any rate compared with what might be effected by spending more upon the cars and track. In a couple of instances mentioned by the author, it appears that at one electric tramway power house 425 H.P. was installed for nearly £6,000; in another, 300 H.P. cost a little over £6,000; the operating expenses per car mile were respectively 5d. and 7d., and the indicated H.P. per car used 47 and 75. Twice as many cars were in service on the first line as on the second, and it had better track and line in a still larger proportion, costing £4,000 a mile as against £1,700. It therefore paid well to invest capital in good track and overhead constructions, and in plenty of cars (thereby reducing the cost of car labour per mile run, owing to the quicker service), rather than very expensive but efficient steam engines in the power house.

Mr. Davis gives several tables embodying the results of his researches into this matter, based on figures supplied by 58 electric lines. The coal consumption on these lines averages out as follows:—

Type of engine.	No. of lines.	Consumption in lbs. per car mile.		
		Highest.	Lowest.	Average.
Corliss	9	22·0	9 2	14·5
Corliss condensing	7	13·4	5 0	9·2
Compound Corliss condensing ...	7	10·9	5 2	8·0
High speed...	13	23 7	7 5	15·0
High speed condensing	3	16·5	9 4	13 7
Compound high-speed condensing	3	19 5	5 4	10 5

AN ELECTRIC YACHT.

It has been the misfortune of the storage battery, says the *American Electrician*, that Lord Kelvin's sensational and theatrical introduction of the Faure cell to the public led to electric storage becoming the favourite theme of the freak newspaper writer, and excited in the minds of the non-technical the most unbounded expectations as to its possibilities. Marine propulsion was one of the favourite presumptive applications, and most enticing hopes were held out as to the revolution the storage battery would work in the conduct of ocean travel. As years went by and it was found that the great promises were not realised, the inevitable reaction followed and electric storage received the cold shoulder from every side.

Though one of the earliest applications of the storage battery was to the propulsion of small boats, the Seine and Thames having been the scene of operation, the disfavour referred to resulted in a cessation of effort in this direction until the fleet of electric launches at the World's Fair caused a renewal of interest. At the present time, the electric launch industry is a growing one, being founded upon a basis that

recognises its limitations, and is therefore not apt to again come into disrepute.

The most extensive application yet made of electric storage boat propulsion is in the electric yacht *Utopian*, designed by Mr. Charles D. Mosher, and launched last fall from Ayre's shipyard at Nyack-on-the-Hudson. The yacht is the property of Mr. John Jacob Astor, who is an enthusiast in whatever pertains to electricity.

The *Utopian* is 72 feet over all, 12 feet beam, and has a draft of 4 feet. Mr. Mosher has introduced some original features into the design of the hull. There is a channel way for each of the twin propellers, so arranged that the screws always work in solid water, which provision is quite necessary when it is considered that the screws at full speed revolve at the rate of 1,200 r.p.m. The stern is also peculiarly shaped with this object in view. Below the water line the shape is much like that of a scow. Above the water line the curves are given a graceful shape that suggests former types. The combination causes the boat to have rather an odd appearance in dry dock, the stern having a peculiar heel shape. This is said to be the very latest improvement in the design of high speed screw driven yachts. The arrangement makes it difficult to clear the propellers when they become entangled with weeds, and as the boat is to cruise largely in inland waters, this might constitute an objection, but in other respects this form is said to be highly desirable. The boat is fitted with two centre boards of Tobin bronze, which may be raised or lowered by electric winches from the promenade deck. It has also an electric capstan and an air pump run by electric power which compresses air to a pressure of 150 lbs. per square inch to blow the boat's whistle. The capstan motor is of 1 kilowatt capacity, geared to the capstan in the ratio of 60 to 1; the same motor also runs the air pump above referred to. The boat is supplied with an elaborate electric signalling system. The owner or captain has at his service, both from the bridge and below, 14 push buttons connecting with an annunciator in the galley and other quarters of the boat, this giving him at all times entire control of the yacht.

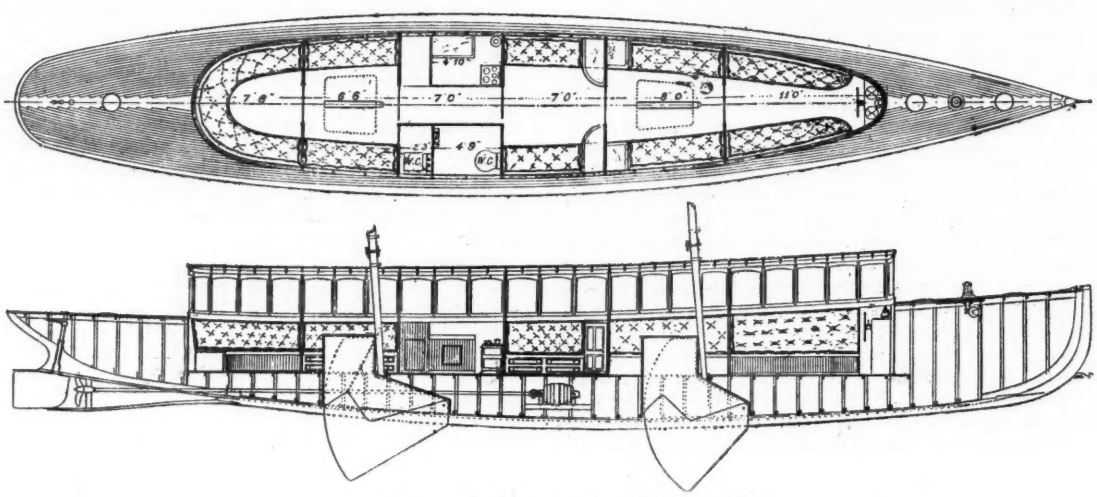
In the construction of the boat no expense has been spared, the decks, planking, and exterior finish being of polished mahogany, except the gunwales, which are of quartered oak. A low brass railing is worked around the deck at each end, and all of the various deck fittings are of polished bronze.

Figs. 1 and 2 give an idea of the arrangement of quarters. Forward there is a cockpit 11 feet long, with windows and seat transoms on each side, the forward windows being fitted with bent glass. In this compartment are a preventer steering wheel and motor controllers, as well as the usual ship working equipment of compasses, speaking tubes, and signal fittings. A second controlling station is provided on the hurricane deck. The spindles on which the hand wheels in the forward cockpit are attached extend upward through the hurricane deck, and are provided at their ends with a second set of hand wheels. This, together with the devices for controlling the search light and steering the boat, make as complete a controlling station on the hurricane deck as in the forward cockpit, a convenience that will be appreciated in warm weather, when this boat will probably be most used. All of the woodwork of the cockpit is in mahogany, and the seats are upholstered in leather.

Abaft the cockpit is the saloon, which is 8 feet long and the full width of the boat. The seats on either side are arranged to fold out and form wide berths. Under the seats are drawers, and at the after ends of the saloon on each side are buffets. The saloon is also supplied with a folding table.

Next abaft the main saloon are the owner's quarters, 7 feet long and the full width of the boat, fitted with seats on either side, so arranged to be used as berths, and with buffets at the forward end. Abaft of the main saloon on the port side is a galley fitted with ice chest, sink, French range, dish racks, closets, &c., while on the starboard side is the owner's toilet, with all modern accommodations. Abaft of these are the crew's quarters, 6 feet 6 inches long, extending the full width of the boat, and fitted with seats, folding berths, with lockers and drawers underneath, and a folding table. Abaft the crew's quarters is the after cockpit, 7 feet 7 inches long, the seats of which are upholstered in leather.

The boat is also provided with sail power, being rigged as a two-masted schooner. The masts are hinged so that they may be lowered when desired. The sails consist of a jib, foresail, and mainsail. The lighting of the boat, of course, is electric. The bulbs of the incandescent lamps have the shape of an oblate spheroid. Three wires are sealed into their edges. Two of these form conducting wires and the third is merely a support. The lamp is suspended horizontally by three platinoid springs in the focus of a spherical reflector, and covered with a crystal on which is etched the initials J. J. A. The ceilings are studded with these lamps and their illumination is very pleasing. On the hurricane deck is a Rushmore 1,200-C.P. search light which can be operated both from the deck and from below.



Figs. 1 and 2.—Electric Yacht "Utopian."

The search light is 10 inches in diameter and ordinarily takes 6 amperes at 50 volts, though it can be worked at 8 and 10 amperes. The light is thrown in a clear solid stream without spreading and will show a buoy at night ½ mile distant. The lamp carries the carbons in a horizontal direction; it contains no screw rods or contact devices, and is operated by a single electro-magnet.

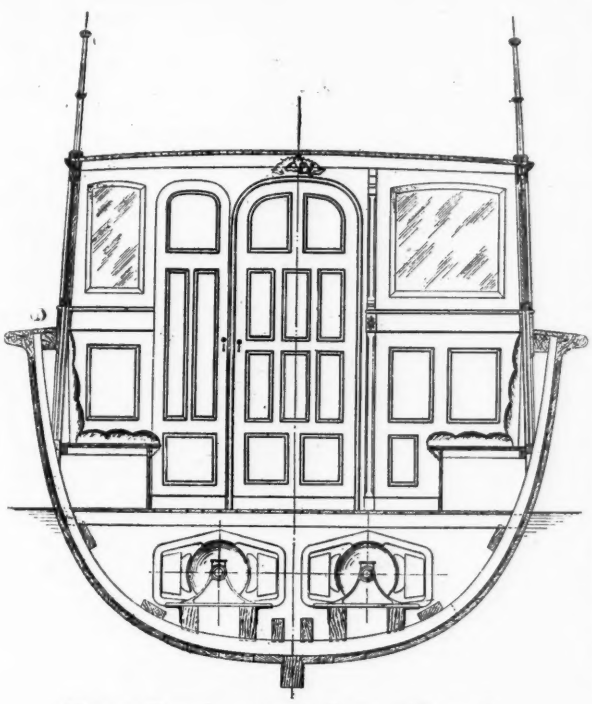
The twin screws of the boat are 30 inches in diameter, and have three blades each; they are designed to drive the boat at a maximum speed of 16 miles per hour, corresponding to 1,200 r.p.m. Each screw shaft is direct connected to the armature of a Riker 25 kw. motor situated underneath the floor of the main saloon.

The motors weigh only 1,168 lbs. each, and have a guaranteed efficiency of 85 per cent. at full load, and will withstand an overload of 100 per cent. for four hours. The armature is of the hollow drum type with a wave winding, the coils being form wound; the brushes, which are of carbon, are 90° apart, and the commutator

is of most generous size. The entire electrical equipment, including battery, weighs but little more than 12 tons.

The fields are of steel, and have four poles; two of these have windings, and the other two are consequent poles. The motors at full load take 125 amperes each at 200 volts, driving the screw at 1,200 r.p.m. The fields are in series with the armature and so arranged that the two bobbins may be thrown either in parallel or in series. The fields and groups of cells are capable of being arranged in eight different combinations by means of controllers very similar to an electric railway controller, being cylindrical in shape, and worked by a geared hand wheel. The controllers which, as well as the entire electrical equipment aside from the batteries, were furnished by Mr. Andrew L. Riker, are in duplicate, one being located on the hurricane deck and the other in the forward cockpit.

The storage batteries are of a new system having no grid plates, and were furnished by the Samuels Dynamic Accumulator Company, of New York. The positive plate is solid, very hard and dense, and is said to improve in its durable



Midship Section of Astor Yacht "Utopian," Showing Motors.

qualities with use. Each cell has 11 plates weighing 26 lbs., the cell complete with electrolyte being claimed to weigh only 50 lbs.

Each screw has its own controller and battery, the latter being of 300 ampere hours capacity, and consisting of 204 cells. The cells are divided into six independent groups of 17 pairs of cells each—each pair being in parallel and the 17 pairs in series, this giving 34 volts for each group.

The six groups by means of the controller can be thrown into four different combinations. As the motor fields may either be in series or parallel, this gives eight different speeds for the propellers.

The first combination is of the six groups in parallel, giving a voltage of 34; with the fields in series the slowest speed is attained, which is increased when the fields are thrown in parallel. In combinations 3 and 4, the groups are arranged three in parallel, giving a voltage of 68, and two different speeds corresponding to the series and parallel grouping of the fields. In combinations 5 and 6, the groups are in parallel by pairs, giving a voltage of 102, and in the remaining combination—7 and 8—all are in series with a voltage of 204. The first four combinations are employed both for backing and ahead, and the latter four for ahead alone.

HIGH VOLTAGE LAMPS AND CENTRAL STATION PRACTICE.

By G. L. ADDENBROOKE.

Early in the year I had the curiosity to make some enquiries as to how this movement was progressing, and noticing from recent correspondence that the information might be interesting, I have endeavoured to form a list of the stations using high voltage lamps up to date. I cannot absolutely guarantee the accuracy of all the details in the following list, but most of the information comes from reliable sources and can I think be taken as substantially accurate, though in some cases I am unable to specify to what extent the lamps are in use.

Station	Volts.	Remarks.
Aberdeen	220	
Burnley	200 or 220	
Bradford	230 ...	Compulsory.
Birkenhead	230 ...	Compulsory.
Belfast	220 ...	Just changing over.
Chester	210 ...	Compulsory.
Cheltenham	200	
Dewsbury	220	
Dundee	200 ...	Not much in use yet, but likely to increase.
Edinburgh	230 ...	Complete change in progress.
Glasgow	200 ...	Intends changing to. New work now at that voltage.
Guildford	220 ...	Not yet working.
Harrow-on-the-Hill ...	220 ...	Compulsory.
Holloway	220 ...	G.N. Ry. central station.
Hove	220	
Kensington and Knightsbridge Electric Co.	200 ...	Compulsory new customers.
Llandindrod Wells ...	230 ...	Starting up.
Manchester	200 ...	Using some lamps.
Nottingham	200 ...	The Castle Museum are extending.
Notting Hill	200 ...	Optional 2d. reduction per unit to customer's taking.
Oldham	210 ...	
Oswestry	220 ...	
Preston	220 ...	
Richmond, Surrey ...	220 ...	Partly.
Shrewsbury	200 ...	Partly, and think of changing.
Southampton	200 ...	Extension works.
Southport	200 ...	
Southend Pier	220 ...	
St. James and Pall Mall Electric	220 ...	Option given to consumers.
St. Pancras Vestry ...	220 ...	Compulsory new work.
Wandsworth	200 ...	Compulsory.
Westminster Electric Co.	200 ...	
Croydon	200 ...	Compulsory.
Bury	220 ...	
Blackpool	200 ...	
Liverpool	220 ...	
Taunton	200 ...	
Tunbridge Wells ...	220 ...	
Islington	200 ...	Compulsory new work.

In addition to the above places, eighteen months since I recommended a 220 volt system for the lighting of Coolgardie, and the installation, which has now been running nearly a year, will soon be larger than that of a good many English towns. No difficulty has been found in sending the lamps so far. I also hear that a town in New South Wales is following suit, and that high voltage lamps are in use in India, though I have no precise information where.

Coupled with the satisfactory results of his experience, which Mr. Gibbings, who succeeded Mr. Baynes, the inaugurator of the movement at Bradford, has lately given, and which I can corroborate from what I hear from other quarters, and from my own experience, this list speaks for itself, and needs no comment.

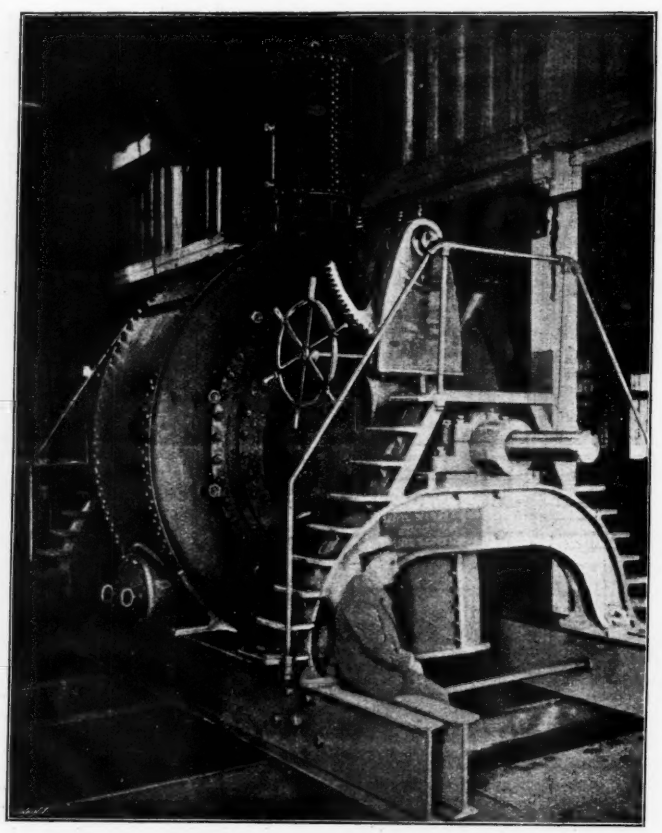
Convinced as I have been of the soundness of the movement, I must say I had no idea it would attain such strength in such a short time, especially as it is only recently that the leading makers of installation material have brought out complete sets of switches, cut-outs, &c., adapted to the higher voltage. Now that these are procurable, at such a very slightly enhanced cost, and as the working of the lamps themselves has been so very satisfactory, it is not going very far to say that the use of the higher voltage must on central station circuits become almost universal before long.

As to what influence the general use of higher voltage lamps will exert on the methods of working central stations themselves, there seems little to add to the calculations and conclusions in my Institution paper last year, which experience now shows to have been very conservative.

I am under the impression that we are ahead both of our Continental and American friends in this matter.

A TWO THOUSAND HORSE-POWER TURBINE.*

The hydraulic and electrical installations at Niagara Falls offer some of the most interesting engineering features in the world. We illustrate one of the enormous turbine wheels of the new plant of the Niagara Falls Hydraulic Power and Manufacturing Company, which has been recently completed, the machinery being now in operation. The plant was built for the purpose of supplying the new aluminium factory of the Pittsburg Reduction Company and to supply power to other consumers. The company now furnishes power to the Niagara Falls and Lewiston Railroad and the Lewiston and Youngstown Railroad. The water supply for the plant is taken from the upper Niagara River. The water flows through a canal 4,400 feet long, 70 feet wide and 11 feet deep to a basin 400 feet long and 70 feet wide which runs parallel to the high bank.



The water for the new power house is taken from a basin to a forebay, 180 feet long, 30 feet wide, and 22 feet deep, located on the extreme edge of the high bank. Over the forebay is built the gate house which covers the gates controlling the admission of water to the penstocks. There are also two waste gates, each 20 feet deep by 8 feet wide, by which the canal may be cleaned at any time. The apparatus for handling these gates was devised by Mr. Wallace C. Johnson, chief engineer of the company, under whose immediate supervision the entire plant was erected. Before each pair of gates are two cast-iron cylinders about 8 feet high with pistons; the two ends of each cylinder are connected to a pump driven by an electric motor, by which the oil with which the cylinders are filled is pumped into either end at will, forcing the pistons to move accordingly. The piston rods are connected by an iron beam on which are hooks taking hold of pins on the gates. With this apparatus it is said that a pressure of 100,000 lbs. may be maintained.

The power house is 180 feet long and is arranged to eventually contain 16 wheels of about 2,000 horse-power each. The wheels work under a maximum head of 218 feet, the highest head thus far used for such a large power. Owing to the fluctuation of the height of the water in the lower river the generator floor of the station was built some 20 feet above the normal water level, and in order to connect the water wheels directly to the generator shafts it was necessary to have them also at the same elevation. It was found necessary to use turbine wheels mounted on horizontal axes to give the necessary speed regulation requisite in a direct connected plant. The penstock runs down vertically 135 feet and is 8 feet in diameter, being built of steel plates. After reaching the bottom of the vertical fall the penstock runs at an angle of 45° and then runs horizontally under the floor for a distance of 70 feet; the size of the penstock is here increased to 10 feet in diameter.

The water is supplied to the turbines from underneath. Valves are provided so that each turbine can be cut off from service if desired. There are at present four turbine wheels installed. They are each of 2,000 horse-power and run at 280 revolutions per minute.

The turbines were built by James Leffel & Co., of Springfield, O. Each turbine takes water from a separate 5 foot pipe leading from the penstock. Each wheel weighs about 50 tons and stands on heavy double steel beams spanning the tailrace. The water pressure is 100 lbs. to the square inch. The Leffel Company call this wheel their "Niagara type." The turbine shown in our engraving is a double discharge turbine and consists of a large flattened vertical circular casing containing the guide case of the wheel proper. The cylindrical case is 11 feet in diameter and 4 feet long. On the side of this case elbows are fitted through which the discharge water is conducted from the wheels. The shaft passes through these elbows, which are provided with stuffing boxes. On the inside of the elbows lignumvitæ steps are fastened, against which are concaved rings on the shaft to prevent end motion on the shaft. The wheels are so designed as to prevent end thrust of shaft. The heads of the casing are made of $3\frac{1}{2}$ inch iron castings. The straight or cylindrical part of the casing is made of steel plates $\frac{3}{4}$ of an inch thick, double riveted to the cast heads.

The runner is made of bronze and iron and is 74 inches in diameter. The rim of the runner is the bucket rim and is cast solid from gun-metal bronze. On this rim are two sets of buckets taking water on the face and discharging it at each side of the rim. The bucket ring is bolted to the spokes of the cast-iron centre, the hub of which is keyed to the shaft of hammered iron, which is 20 feet in length. Surrounding the outside of the runner is a cylinder in which the gates are fitted. The gates are about 20 per cent. less in number than the buckets; they are hung on steel pins and open by lifting one edge, so that the direction in which the water enters the wheel is nearly tangential to the runner. Each gate has two arms, which are connected to the ring by means of which they are opened and closed. The wheels operate under a variable head of 210 feet to 218 feet and run at a speed of 280 revolutions per minute. To each end of the water-wheel shaft is rigidly coupled a direct current genera-

* *Scientific American.*

tor capable of generating 560 kilowatts of electrical energy.

The power company have also four turbines of the same type and make. Two of these turbines are of 2,400 horse-power, and connect with eight powerful pulp grinders, situated on each side of the wheels and connected directly with them in a manner similar to the generator connections above mentioned.

MEASURING THE CABLE CURRENTS EXISTING DURING A CONDUCTOR RESISTANCE TEST.

In a letter under this heading, published last week in a contemporary, Mr. N. C. Christophersen expresses his opinion that "the best method for finding the E.M.F. of an earth current present during an ordinary copper resistance test seems to be the one embodied in the formula" which he gives, but he does not explain why, or give any figures showing that his results are more exact than those obtainable from other well known tests, such as for instance:—

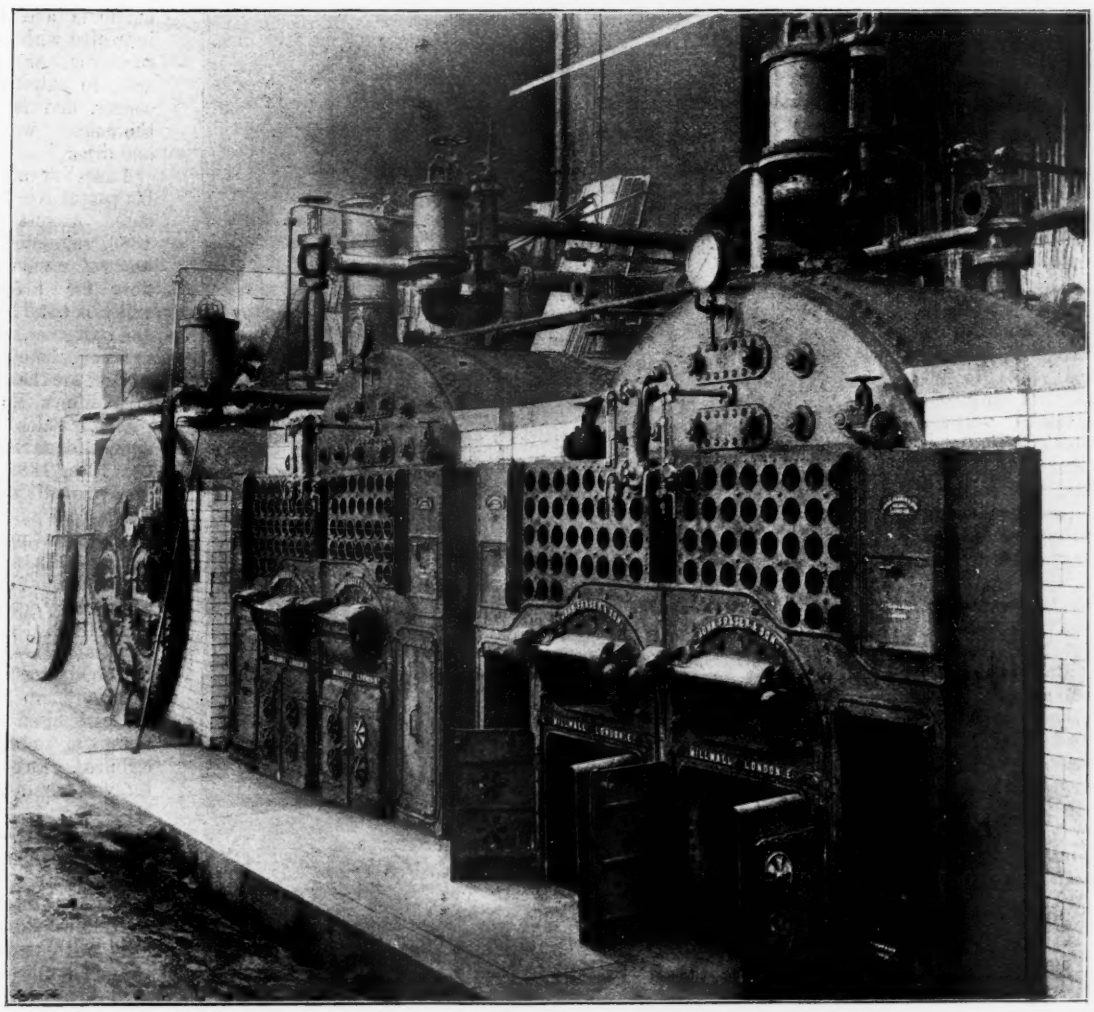
(*a*) Testing with reverse currents by Bridge (Schwendler's method).

(*b*) Reproduced deflection method of measuring the total resistance (R) in circuit, where the deflection through the cable is reproduced with resistance coils—allowance being made for the cable current deflection.

(*c*) Mr. Schönan's test recently described, and other tests of a similar character.

In methods *b* and *c* a resistance equal to that in the cable circuit may be substituted in the place of the cable, and the deflection obtained through it from a standard cell compared with the deflection from the cable current as observed on a dead-beat galvanometer after taking off the testing battery.

With regard to the special test recommended, Mr. Christophersen first measures the resistance in the cable circuit by Kennelly's false zero method,* after which a resistance equal to this measured resistance has to be substituted for the cable in the Bridge system, and the substituted resistance altered till a balance is obtained to the same false zero deflection as observed in the first part of the test, in addition to which the E.M.F. of the testing battery has to be separately determined. It does not, therefore, appear that any special advantage is gained or testing facilitated by the formula recommended so far as an ordinary copper resistance test is concerned. With regard to a broken cable the same weak point exists in the test under consideration as in Mr. Schönan's test, and in all tests where the balance is made to false zero, viz., the difficulty in determining what is the true false zero at the moment when the balance has been obtained, owing to the discharge from the cable, and the change in the polarisation current which rapidly falls as soon as the testing current is taking off.



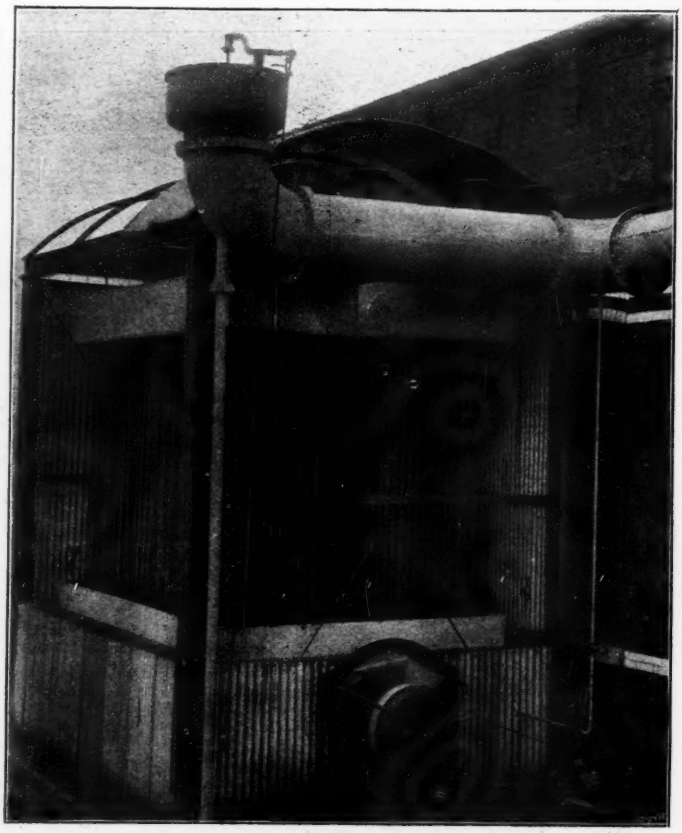
Fraser's Improved Dry Back Marine Boilers.

For measuring the C.R. of a perfect cable it is best to employ one of several well-known tests which are capable of giving a result from which the effect of the cable current is eliminated; and in the case of a broken cable a result independent both of the cable current and the resistance of the fault. If it is required to record also the E.M.F. of the cable current, it can be more accurately determined by comparison with the known E.M.F. of a standard cell by means of a condenser, or by a potentiometer test, either before or after the C.R. test, or at any other time of abnormal disturbance when it may be of interest to measure it.

* This first part of the test is subsequently referred to as a *localisation* test—a designation which is scarcely appropriate since the measured resistance includes the resistance of the fault which sometimes may even exceed the conductor resistance of the cable.

THE INCANDESCENT LAMP SITUATION IN AMERICA.

The last few numbers of the New York *Electrical Review* and the *Electrical World* for February 13th, contain some rather surprising announcements regarding the policy which is being pursued in the States by the Westinghouse Electric Company. This organisation it appears has gathered under its control a number of patents connected with the manufacture of lamps, and particularly some relating to the manufacture of filaments, by which it hopes to control the lamp trade in America. Amongst these is a notable one of Edward Weston for making filaments from homogeneous structureless cellulose, and it is, apparently, on this patent that reliance is principally based. The patent was issued in 1882, and it is claimed that it covers all the homogeneous cellulose filaments which are now so largely used. Besides this, the company is said to own a patent which "covers fibrous filaments such as twisted or braided silk, treated or untreated, and a third a method of treating filaments." The total number of patents held is, according to one account, from 40 to 50, and according to another 72, all of which relate to incandescent lamp construction. Already the bulk of the lamp undertakings in the States, including all the prominent ones, have applied for and been granted licenses on very moderate terms, to manufacture under these patents; whilst legal proceedings are being instituted against some of those who have refused to take out licenses. Prominent amongst those who refuse is the Shelby Electric Company, who use square cut filaments which are hard enough to "scratch glass very readily." They are the invention of Prof. Chaillet. It is further stated that the principal of these Westinghouse patents have still some six years to run.



Fraser's Patent Evaporative Condenser.

With regard to the claim based on Weston's patent, it should be borne in mind, in weighing its value and controling power, that the bulk of homogeneous filaments as now manufactured is made by methods and chemicals entirely different to those described in the patent in question. Weston specified, firstly the preparation of nitro-cellulose in the form of sheets of collodion or celluloid; secondly, the cutting up of the sheets into filaments; and, thirdly, the denitration of the compound, by means of certain chemicals, back again to cellulose. The general procedure to-day is to dissolve cellulose pure and simple, in a solution of zinc chloride, to squirt the compound solution into spirit, and finally to wash and dry the thread. This process, which was invented and first used industrially at the Brush Company's works in England, was never patented in America, and is therefore public property in that country. The resulting material produced by this process, whilst it may resemble in some particulars that produced by Weston's process, is brought into existence by wholely different means. But even if the different method of preparation should be held of no account, was Weston the first to use cellulose in a structureless form for filaments? Here is an extract from an English patent of Crookes, which was applied for in June, 1881, and which was completed on December 15th of the same year:—

"Another very convenient process for making carbon filaments by my invention is to take a loose form of cellulose, such as cotton wool or Swedish filtering paper, and allow it to remain in the cuprammonia solution until it is *entirely* dissolved, or nearly so; the liquid is then poured into a very shallow dish with an accurately level bottom; the ammonia and water are allowed to evaporate, leaving a film or skin of cupric cellulose covering the bottom of the dish. This film or skin, when it has acquired a sufficient consistency by the evaporation of the ammonia and water is treated with nitric, sulphuric, or other acid, to extract the copper, and is then thoroughly washed and dried."

Lane-Fox also, in his patent No. 3,494, dated August 28th, 1880, suggested the use of vulcanised fibre for filaments, which is to all intents and purposes, structureless cellulose.

Here are the claims of Weston's English patent, which was applied for on September 19th, 1882, and completed March 19th, 1883, the American patent having been applied for on March 7th and completed September 26th, 1882.

"Claim I.—A carbon conductor for an electric lamp made of carbonised non-fibrous or amorphous cellulose, substantially as herein before set forth.

"Claim II.—The process for manufacturing carbon conductors for incandescent lamps, which consists in first converting cellulose into celluloid or collodion, then treating it with reducing or dioxidising agents to convert it into non-fibrous or amorphous and homogeneous cellulose, and finally forming therefrom conducting strips and carbonising the same, substantially as herein before set forth."

Weston took out a patent in America for preparing amorphous cellulose by the cuprammonia method the same date as his celluloid patent.

What value the rest of the patents belonging to the Westinghouse Company may have it is impossible to say at present, as no particulars of them are given in the journals we have perused.

FRASER'S BOILER AND CONDENSER.

Electrical engineers have been for some time on the look out for condensers which will give 24 inches to 25 inches vacuum to their engines with very small water consumption. The condenser illustrated above has been designed with this object, and by means of it

condensing engines may be used with a total water consumption for all purposes of about 10 per cent. less than when working with ordinary high-pressure engines. The methods adopted are as follows:—At the top of condenser are placed the steam receivers which are coupled by means of an omnibus pipe to the general exhaust main at the station, controlled by independent valves so that any one section of the condenser can be cut off.

At the end of the exhaust main is placed an automatic relief valve so that the exhaust steam can be immediately exhausted to the atmosphere in the event of anything happening to the condenser. These top joint receivers are connected to similar receivers but of smaller sectional area, at the bottom, by means of vertical brass tubes, preferably of 1¼ inches diameter and about 9 or 10 feet long. The cooling of the tubes is effected by running down each one a thin film of water, and it is the evaporation of this water which gets rid of the heat from the steam which is inside the tubes, and produces the required vacuum. This evaporation is greatly increased by causing air to pass rapidly over the surface of the tube at the same time. In the ordinary way the air would blow the water to one side of the tube with the result that a thick stream of water would be running down the back of the tube while the front of the tube on which the air was blowing would be dry and therefore doing practically no condensing work.

Messrs. John Fraser & Son, of Millwall Boiler Works, claim to have got over the difficulty by placing on every tube a collection of dished cups or conical washers connected together by vertical rods ¼ inch wide × ⅛th thick. These cups collect the water at every 12 inches and replace it in its proper position on the tubes. We understand that the reason of their being placed 12 inches apart was because it was found from experiment that, with an average current of air passing the tubes, it is at 12 inches the water goes to the back. Another function of these cups is that they scrape off the surface of the tubes carbonite of lime and magnesia which are left on the outside by the evaporating water.

For each 1,000 lbs. of steam from the engines that are condensed on the inner surfaces about 900 lbs. of water are evaporated off from the outer surface; it is, therefore, stated that a water saving of about 10 per cent. is in this way effected by using condensing engines instead of high pressure and instead of increasing the water consumption about 20 times, as is usually the case when surface condensers are employed. The water which runs down to the bottom of the tubes is collected in a bottom tank and re-delivered into the upper distributing tank.

Engineers are, of course, well aware of the enormous saving which is obtained by adopting condensing engines, more especially when the engines are properly proportioned, say, of the marine type with large diameter of low pressure cylinder. As a matter of fact, we are informed that at one well known electric light station the actual working result showed that the triple marine type engines, working with a condenser, produced a given result at a cost of ·5d., as compared with a cost of ·83d. at the same station when working their compound engines, which are non-condensing. Messrs. Fraser are also introducing a circular type of evaporative condenser for use in certain places where very small space is available.

The whole structure being very light can be placed on top of a roof, which is claimed as a great advantage over other forms of evaporative condensers consisting of rows of cast-iron pipes.

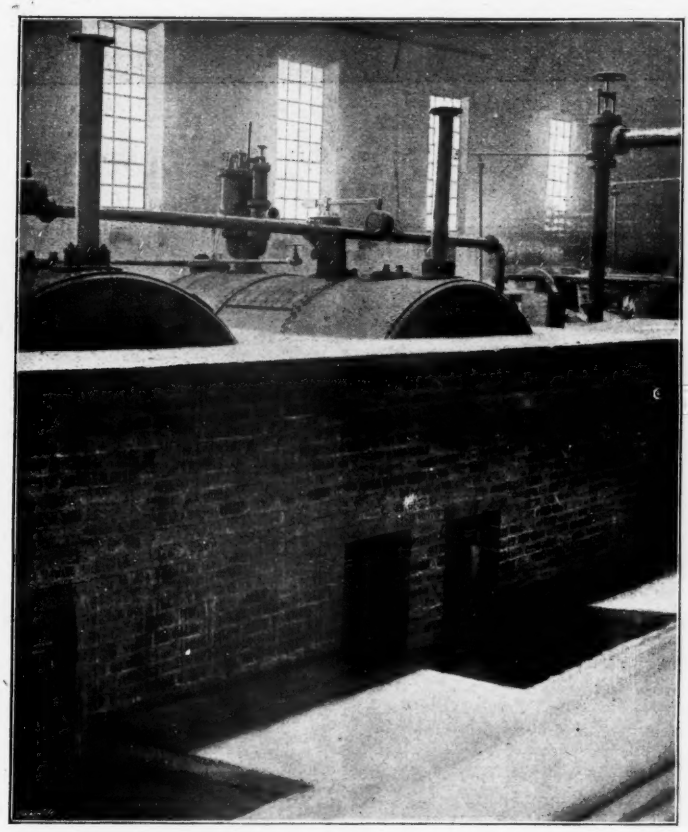
It is stated that 1 square foot of tube surface in this condenser will condense 12 lbs. of steam per hour. In the old form of evaporative condenser 1 square foot did on an average 1 to 1½ lbs. It would, therefore, seem that by this arrangement eight times the work can be done per square foot, and, consequently, initial cost of putting up the condensing plant is largely reduced.

We also illustrate the Fraser improved dry back marine boiler, which this firm have introduced with a view to meeting the demand for an economical type of boiler. For the purpose of cleaning all the heating surfaces, ample spaces have been allowed; the tubes are kept well clear of the furnace crowns, and sufficient room is left between the two rows to allow a man to get down.

The air for combustion is heated by means of the surplus heat from the waste gases before they pass to the chimney.

Each pound of coal takes 18 to 20 lbs. of air to properly burn it; by raising the temperature of this air 200° it is claimed that an economy of 5½ per cent. is obtained quite independent of the more perfect combustion resulting from the higher furnace temperature. The flues are exceptionally large and a chamber is provided under the boiler for collection of dust and soot (the boiler itself being supported above the soot by means of iron girders which also keep it free from damp and enable any part of the shell to be examined). The soot and dust can be removed during the time the boiler is at work, six air tight cleaning doors being provided for this purpose. The air heating tubes are cleaned by patent travelling scrapers which move freely along the tubes. The fire tubes have a stopper placed in front of each to enable them to be easily swept out. Every part of the boiler is accessible for repairs should they be required.

The boilers are stoked in the ordinary way, the flames pass over the bridges to the back combustion chamber, which becomes incandescent and thereby ensures perfect combustion before the gases enter the tubes; after passing through these fire tubes to the front smokeboxes they return through the side flues past the outside of the air-heating tubes and out to chimney shaft or economiser flue. The air for combustion passes in at the back of boilers through the air-heating tubes and out to the front hot-air chamber, thence the hot air passes under the fire bars, and also through the smoke-consuming regulating valves as usual.



Back View of Boilers Showing Entrances of Cold Air to Air Heating Tubes.

FRENCH SUBMARINE CABLE LAYING AND REPAIRING STEAMER "PORTENA."

Messrs. Johnson & Phillips, of Charlton, have just completed another cable steamer equipment, this being to the order of the Campagnie Française des Cables Telegraphiques, of Paris, and making the third carried out by this firm within 12 months.

The work consisted of transforming a merchant vessel into a cable laying and repairing steamer, and, although the vessel was not a new one, it adapted itself fairly well for the purpose, especially as regards the cable tanks, though it had high forecastle bridge and poop decks, and a comparatively small beam, viz., 33 feet, while it was 320 feet long.

The picking-up and paying-out machine was built very much on the lines of that for the steamer *Tutanekai*, lately fitted by this firm for the New Zealand Government, but was much more powerful, being equal in strength to that recently fitted on the ss. *Okinawa Maru* for the Japanese Government.

Owing to the vessel having a high forecastle and bridge deck, it was necessary to instal this machine on the upper deck, and, therefore, it had to be self-supporting. For this reason the frames of the machine, which were constructed of steel plates and angles, were tied fore and aft by strong wrought-iron diagonal stays, whilst additional stays were fitted in the nature of flat and angle bars, and various fixed shafts were also utilised for this purpose.

The method of securing the machine in the vessel was a very rigid one. Channel bars 12] inches wide were bedded on to the steel deck so as to present a perfectly level surface, and the machine was levelled up on this by means of cast-iron wedge chocks, large pitch pine bulks being fitted between and below the beams under the deck. The deck itself was stiffened by two-plate girders 2 feet deep at centre, fixed underneath, right across the vessel, and attached to the shell plating, and these girders and the deck beams under the gear were stayed by stanchions right down to the keel and floor of the

vessel. This made a splendid job, as even with the gear running at full speed not a slightest vibration could be felt at the trial.

The gear is driven by a pair of horizontal engines having cylinders 15 inches diameter by 15 inches stroke, which, running at 220 revs. per minute, are capable of developing 210 brake horse-power, with steam 70 lbs. initial pressure.

The engines are fixed at the after end of the machine, and over them is erected a platform from which the attendant can work and regulate the whole of the machine, the stop valve hand-wheel, reversing lever, drain cocks, main brakes, draw gear, brakes, and water service all being within easy reach.

Ladders are fixed at each side of the platform, which is also provided with polished hand rail, and the whole forms a very neat and compact arrangement.

As in other gears now made by this firm, the parts are constructed mostly of steel to insure lightness and strength. The total weight of this machine is 23 tons.

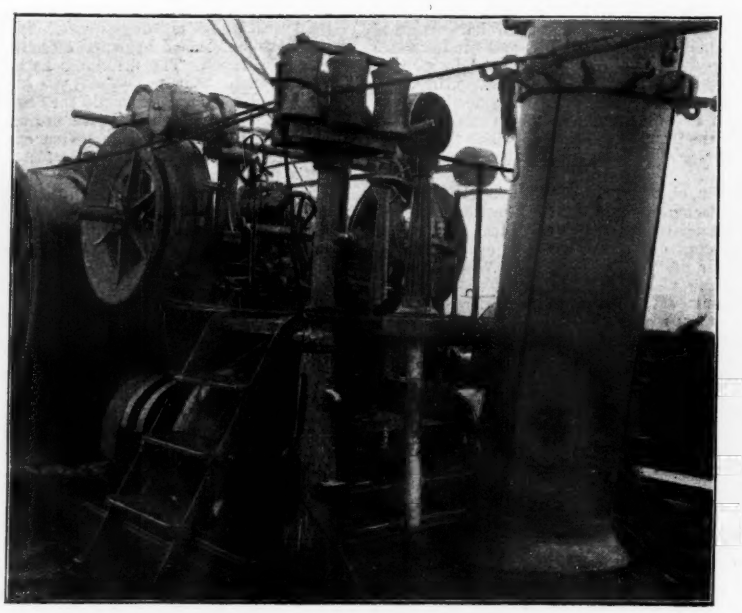
The main drums are internally geared and a rim is cast on for the brake, so that the drums can revolve under the control of the brake independently of any other gear.

The geared pinions are made to draw out of gear when not required for working so as to avoid rattling.

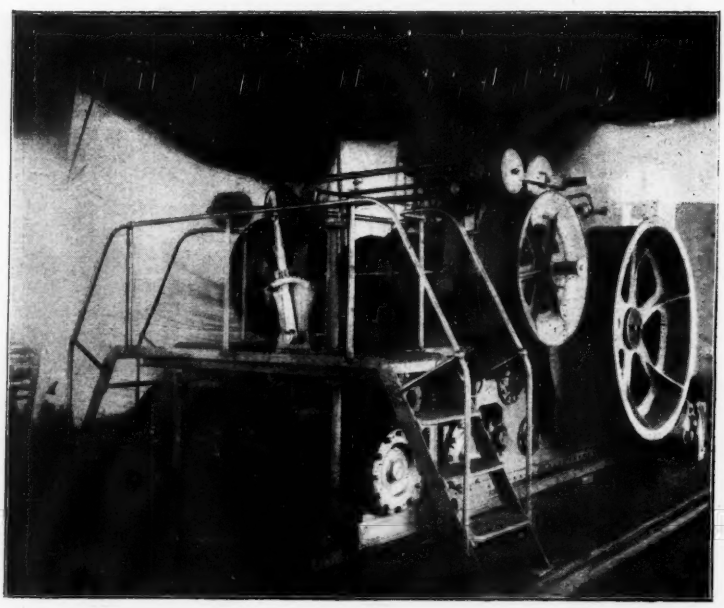
The "hauling-off" gear is driven by special silent pitch chain when picking up, but when being used as "holding-back" gear for paying out the sheave (which also has a brake rim cast on) is arranged to run loose on a sleeve, being controlled by its own brake.

A small Worthington pump is provided on the platform to work the water service, which is fitted to all the brakes.

A special feature of the main brakes, which are actuated by screws, is that they are worked through worm wheels and worms, so as to give finer adjustment for paying-out as well as great power for holding. It will be readily seen that with the intervention of the worm wheel and worm, a very fine movement of the brake screw can be obtained with very little power exerted at the hand-wheel on the worm spindle, and when it is necessary to release or apply the brakes quickly, it is only necessary to spin the hand-wheels round two or three turns, which is readily done as they work so easily.



SS "Portena" Cable Gear.



The bow gear consists of three steel sheaves running loose on a steel shaft which is carried in dead bearings attached to steel girders which are very rigidly built into the head of the vessel, considerable alterations having to be done to this part to make it suitable for the bow gear. The plating of the ship is made up to the girders and "whisker guards," give it a very neat appearance.

The stern gear consists of one steel sheave running loose on a shaft and carried on a pair of steel girders secured to the poop deck.

The dynamometers (of which three were supplied) are of extra heavy pattern having two cylinders each, which act as dashpots, an adjustable byepass being provided between each cylinder by means of pipes and cocks so as to steady the movement of the dynamometer sheave.

Owing to the vessel having wells between the forecastle and bridge deck and bridge deck and poop, it is necessary to provide special leads for the cable, and these consisted of strong cast-iron bases secured to the upper deck, and having a wrought iron tube vertically in their centres, which could be adjusted in height, and the usual deck lead consisting of base-plate with rollers and guards for cable, were carried on top of these.

Where the leads could be fixed close to the deck the usual pattern of lead was supplied.

The cable coming from the after tank to the cable gear is arranged to pass through the alley-way, under the bridge deck, and for this purpose about 80 feet of troughing was supplied fitted with bell mouth leads at intervals. The tanks were fitted with the usual arrangement of bell mouths and crinolines.

A "Lucas" patent steam sounding machine was fitted on the after end of the poop for taking deep soundings.

A complete equipment of stores was supplied, including chains, ropes, chains and rope fittings, grapnels, mushrooms, centipedes, buoys, lamps, blocks, cable leads, messenger sheaves, steam and hand hauling gears for turning over cables, sounding shot, tubes, &c., tools, and all necessary accessories.

The outfit of grapnels included Claude Johnson's patent mud and rock grapnels which we have before described, the former having flat steel prongs which offer very little resistance to the mud, and the latter having prongs held in position by spiral springs which allow them to recede under the protection of an annular conical shield when they come against any immovable obstruction, but owing to the special arrangement of the fulcrum of the prongs, only a very slight movement is necessary to insure this, so that if the cable has already been hooked there is no risk of losing it.

The vessel was fitted throughout with electric light, the generating plant being in duplicate, and each set capable of maintaining 150 16 C.P. lamps continuously. There was also a large Admiralty pattern projector, 20 inches diameter, with mirror, and an arc light for the rigging, as well as mast and side lights and deck clusters for the deck when working the cable. The dynamos were of

Johnson & Phillips two-pole inverted pattern, compound-wound, having an output of 140 amperes at 60 volts, when running at a speed of 300 revs. per minute, and they were direct-coupled to Robey engines. The contract for the whole of the work was placed with Messrs. Johnson & Phillips, including the alterations to the vessel, which were most extensive, but this part of the work was executed by Messrs. Dunlop & Co., of Port Glasgow, under contract. The fore and aft holds had to be entirely cleared out in order to allow for water ballast tanks, and the cable tanks being fitted. The work of building in the ballast tanks was very difficult, owing to the construction of the hull, and it involved a great deal of work, especially aft, where it was necessary to renew the whole of the tunnel, which necessitated the lifting of the propeller shaft and the after mast. The cable tanks were built directly on top of the ballast tanks, the forward tanks being 30 feet diameter 18 feet deep, and the after tanks 29 feet diameter, 14 feet 6 inches deep respectively. The tanks were firmly secured at the sides to the hull of the vessel by vertical gusset plates and to the deck by means of strong steel stringer plates. A large Worthington pump is fitted in the engine room to work the ballast and cable tanks, and this also has connections to the main condenser so that can be used as an auxiliary circulating pump for use when the main engines are stopped, or moving slowly, and the cable gear is exhausting into the condenser. A large saloon was fitted up under the poop, the total length being 54 feet, and it contains 12 cabins of various dimensions for captain, officers, electricians, and engineers. The main saloon is 54 feet long by 14 feet wide. New accommodation for the crew and cable hands (50 in all) was also fitted up forward. A portion of the bridge deck had to be cut away to allow for a hatch over one of the cable tanks, and some existing cabins had to be dismantled and formed into a testing room. This room was fitted up by Messrs. Johnson & Phillips with a complete set of testing instruments, &c., by the very best makers. Part of the forward hold under the cable gear was fitted with platforms and cones on which to coil the grapnel and buoy ropes. There are four of these platforms; two on port side and two on the starboard side, one of each being on the floor of the vessel, and the others on the level of the lower deck and immediately over the lower ones. The cones of the upper ones are fitted with bell-mouths in the centre, so that the ropes can be taken right through them to the lower platforms, and there are similar bell-mouths in the upper deck, immediately under the holding-back sheave of the cable gear, so that the rope can be led directly on to them. The necessary ladders are provided for access to these platforms. A new capstan windlass was supplied and fitted in the forecastle, and a new steam winch forward. The dirty state of the ship, as shown in the engraving is eloquent of the condition following the stowing of cable into the tanks in bad weather; the whitewash off the cable playing sad havoc with the appearance of the deck and gear.

The whole of the work has been carried out in the most thorough manner.

THE BRADLEY ALUMINIUM PATENTS.*

In the *Journal* for February 20th, page 182, we referred to the decision of the United States Circuit Court of Appeals vesting in the Cowles Company the title to certain patents issued to Charles S. Bradley. This decision is final, as there is no further appeal possible in a case of this kind.

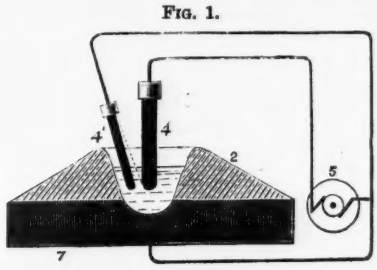
The patents in litigation were three in number: No. 464,933, issued as of date December 8th, 1891; No. 468,148, February 2nd, 1892; and No. 473,866, April 12th, 1892. Of these the second, No. 468,148 is the most important, for the others cover very similar ground. As the matter is of importance in the aluminium manufacture, we give herewith two of the drawings accompanying the patent, and also an abstract of the specifications. The applications for these patents were made in 1883.

According to these, the invention relates to a process of effecting by the electric current the separation or dissociation of aluminium from its ores or compounds, or the decomposition in a similar manner of other like highly refractory metallic compounds of which aluminum may be considered a type. Hitherto this process has been carried on by subjecting the fused ore to the action of the current in a crucible or other refractory vessel placed in a heating furnace where the temperature is sufficiently high to keep the ore in a melted condition; but the greatest difficulty is encountered in preventing the destruction of the crucible with this mode of working the process, for it has been found that, in the case of cryolite especially, which is a double fluoride of aluminium and sodium, the fused ore unites or fluxes with the crucible itself, and that the gas liberated in the process of reduction (fluorine gas) attacks the material of which the crucible is composed, and the consequence is that the crucible is quickly destroyed. This destructive fluxing action takes place to a greater or less extent in treating almost any material and is greatly aggravated by the fact that the crucible is subjected to heat from without, but even in the case of materials which do not exert a fluxing action the mere mechanical action of the external heat is sufficient to make it almost impossible to prevent the cracking of the crucibles. The main object of the invention, therefore, is to dispense with the external application of heat to the ore in order to keep it fused. In order to accomplish this object an electric current of greater strength or intensity than what would be required to produce the electrolytic decomposition alone is used and the ore is maintained in a state of fusion by the heat developed by the passage of the current through the melted mass, so that the electric current is employed to perform two distinct functions, one of these being to keep the ore melted by having a portion of its electrical energy converted into heat by the electrical resistance offered by the fused ore, and the other being to effect the desired electrolytic decomposition, by which means the heat, being produced in the ore itself, is concentrated at exactly the point where it is required to keep the ore in a state of fusion.

Another feature of the invention consists in dispensing with the crucible for holding the ore and in employing a body of the ore itself to constitute the vessel or cell in which the reduction takes place, which is not destroyed by the chemical action of the fused ore and the gas liberated, and which therefore admits of the process being continuous, nothing being required but the charging of fresh ore as fast as the reduction goes on, either from without or from the sides or walls of the heap itself.

According to the description a body of the ore, more or less pulverised, is piled upon a hearth of any suitable material in the shape of a truncated cone, and a cavity or basin is excavated in the top of the heap to contain the fused portion of the ore which is to be treated electrolytically. In order to fuse the ore at the start, two electrodes of a suitable material, such as already used in like processes where fusion has been effected by an external furnace, are connected, respectively, to the two poles of a dynamo-electric machine or other source of current, brought first into contact, then separated sufficiently to produce an electric arc, and then thrust into the ore lying at the bottom of the cavity or basin, where the ore soon fuses by the heat of the arc and becomes a conducting electrolyte through which the current from the electrodes continues to flow. The arc of course ceases to exist as soon as there is a conducting liquid—the fused ore—between the electrodes, and the passage of the current then takes place through the fused ore by conduction and the heat is produced as it is in an incandescent lamp. The arc is merely used to melt the ore in the beginning and the ore is kept melted by incandescence, so to speak, the metallic aluminium being gradually deposited at the cathode and the fluorine gas being set free at the anode so long as the ore is maintained in a state of fusion. As soon as the action is properly started the electrodes should be moved a little farther apart, in order that the metal

Fig. 1.



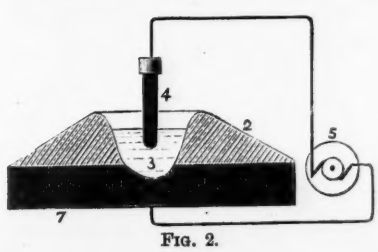


Fig. 2.

set free at the cathode shall not form a short circuit between the electrodes or be attacked by the fluorine set free at the anode. For the purpose of perfectly managing and controlling the process, the electric generator or source of current is so arranged that the strength of the electrolytic current may be properly regulated and the mass of ore thereby kept at the proper temperature. The most efficient way to accomplish this is to raise or lower the electromotive force of the generator by any of the well-known methods employed—for example, in incandescent electric lighting.

It is evident that furnaces of various forms built of various materials may be employed without departing from the invention. Instances of two such modifications are illustrated in the drawings, figs. 1 and 2, which are given. In fig. 1 the body, 2, of ore is heaped upon a slab of carbon, 7, which is connected to one of the poles of the dynamo-electric machine, 5. The electrodes, 4 and 4', are first brought together and inserted in the basin, 3, into the contained ore and then separated to form the arc, as previously described, and when the heat has melted down a portion of the ore so as to form a conductor, the electrode, 4', may be withdrawn and the operation thereafter continued between the electrode 4 and the carbon slab 7. In fig. 2 the arrangement is the same, except that the electrode, 4', is omitted, and in this instance the operation is started by first establishing contact between the electrode 4 and the carbon slab 7, and then the former is withdrawn as soon as a sufficient quantity of fused ore is present to conduct the current and effect the required results.

The claims of this patent are as follows:—

"1. The process of separating or dissociating metals from their highly refractory ores or compounds, non-conductors in an unfused state of which the ores and compounds of aluminium are a type, which consists in fusing the refractory ore or compound progressively by a source of heat concentrated directly upon it rather than by an external furnace, and as it becomes fused effecting electrolysis by passing an electric current there through between terminals which

* *Engineering and Mining Journal.*

are maintained in circuit with the fused bath, whereby the process is rendered continuous, substantially as set forth.

"2. The continuous process of separating or dissociating metals from aluminous or like highly refractory ores of compounds, non-conductors in an unfused state, which consists in progressively fusing the refractory ore or compound, and as it becomes fused, electrolysing it by passing an electric current therethrough of sufficient volume to continue and maintain the fusion and effect electrolysis and adding fresh material from time to time to preserve the bath constant, as set forth.

"3. The process of reducing metals from that class of highly refractory ores and compounds, non-conductors in an unfused state, of which the ores and compounds of aluminium are a type, which consists in fusing a portion of the refractory ore or compound to be treated, in establishing an electric current through said fused portion, and by such current producing simultaneously progressive fusion of such ore or compound and continuous electrolysis of the same as fused.

"4. The process of separating or dissociating aluminium from its ores or compounds, consisting in fusing and maintaining the fusion and electrolytically decomposing the ore or compound by the passage of the electric current therethrough, substantially as set forth.

"5. The continuous process of separating or dissociating aluminium from its ores or compounds, consisting in fusing and maintaining the fusion and electrotically decomposing the ore or compound by the passage of the electric current therethrough and charging the bath with fresh quantities of the ore or compound as the reduction proceeds, substantially as set forth.

"6. The process of separating or dissociating aluminium from its ores or compounds, consisting in fusing and maintaining the fusion and electrolytically decomposing the ore or compound by the passage of the electric current therethrough and regulating the strength of said current in accordance with the requirements of the fused mass, substantially as set forth."

CORRESPONDENCE.

Colwyn Bay Electric Lighting Scheme.

I think the present is an opportune time to give you and the readers of your journal, through the columns of the ELECTRICAL REVIEW, my experience *re* the above competition.

In December I visited that lovely little place for the purpose of taking all particulars necessary for formulating a scheme, assured, at the time, that it would be a fair and square fight, and that the *best scheme* would win.

The town consists of between 6,000 and 7,000 inhabitants; in the season this number is perhaps increased to over 10,000 through the influx of visitors.

It is a well-to-do fashionable watering place. No slums. Full of good modern hotels and residences, two roads containing numerous and high-class shops, and the population a rapidly increasing one. The scheme was to include arc lighting for one mile of promenade, and the whole of the street lighting by arc lamps and incandescent lamps, besides allowing a margin of power for motors for pumping and traction purposes.

After giving the matter great consideration, I arrived at the conclusion that a plant capable of supplying 180 units (3,000 16-C.P. lamps), with building equipment for future extensions, would be the minimum it would be judicious to recommend, and I based my estimates, plans and report, accordingly.

Gas being 4s. per 1,000 feet, consequently a large demand would obtain in Colwyn, therefore it was safe to anticipate that the size of plant would be none too large.

According to the terms of the competition, the plans and schemes were to be submitted by January 12th, so on January 9th I travelled to Colwyn to personally deliver them.

On entering the local offices, I was told by a clerk that, owing to the desire of a local firm of architects, Messrs. Booth, Chadwick & Porter, of Colwyn and Manchester, to compete, the date had been postponed one week; he further informed me that Messrs. Fawcus & Clirehugh were going to draw us the scheme for them, and that Mr. Clirehugh was down at Colwyn that day for the purpose of taking particulars. The surveyor, however, told me that the date had been postponed at the desire of one of the Manchester competitors. I have subsequently learned that this particular competitor has not sent in a scheme at all.

It is needless to state that I did not leave my plans and report behind, but brought them back with me to Manchester; but other schemes, I believed, were sent in.

On January 13th I learned, much to my chagrin, that Mr. Porter, of the firm of architects mentioned, was the son of Councillor Porter, of Colwyn Bay, and brother to the Town Clerk; Councillor Porter being also chairman of the local gas company.

On learning this, I felt greatly annoyed with myself in having taken so much trouble, devoted so much time, and incurred so much expense, and wrote a letter to the chairman, Mr. Parry, bitterly complaining of this extraordinary turn of events, and threatened to withdraw unless an adjudicator was appointed by vote of the competitors; his reply was exceedingly satisfactory, and contained the assurance that all the competitors would receive fair play.

I also wrote to one of the London competitors, Mr. W. H. Tasker, who promised to communicate with the London men.

The date was further postponed a week, until January 26th. Prof. Kennedy received the majority of votes, but, unfortunately, he was too busy to accept the appointment; so without consulting the competitors, the minority man, Dr. J. Hopkinson, was appointed.

I extract from the Colwyn Bay *Weekly News* for March 12th, the result arrived at by that gentleman :—

"I have carefully read all of the 10 schemes submitted for the electric lighting of Colwyn Bay. I am of opinion that the following three are the best, and of substantially equal merit: Bennett, Fawcus and Clirehugh (*Booth, Chadwick, and Porter*), and Highfield, and I would prefer to make an award of an equal division of the prizes amongst the three. Any one of them would be capable of carrying out the work in a satisfactory manner, &c., &c."

In reply to this, the surveyor wrote Dr. J. Hopkinson as follows:—At a meeting of the Lighting Committee, held this morning, in which your communication on the above scheme was read, I was requested to write and ask you if, after considering the enormous difference there exists in the costs of carrying out the work designed by each of the competitors whom you have selected as of equal merit, you cannot further assist the Council by selecting the first and second best out of the three, as they feel confident that works that can be carried out for £7,450 (*Fawcus & Clirehugh and Booth, Chadwick & Porter*), were more suitable and of more merit than similar works which will cost £9,227 (*Highfield*), and £10,500 (*Bennett*). Under these circumstances the Committee feel convinced that some distinction can be made between the three, &c., &c."

The italics are mine.

The answer was as follows :—

"The three schemes I selected differ less from each other in estimated cost than I have often known tenders from contractors tendering to a detailed specification.

"I understand, however, that the Committee desire an award stating which scheme is the best, and which second. I fall back upon the care shown by the competitors in presenting the various schemes, and consider that Fawcus and Clirehugh (*Booth, Chadwick & Porter*) is the best, Bennett is the second, Highfields' is as good as these but less elaboration has been bestowed upon presenting it. . . . . Fawcus and Clirehugh include a battery which might, I think, be advantageously increased in capacity."

In this reply, Dr. J. does not enter at all into the individual capacity of the various schemes, but compares them with contractors' tenders which, as we all know, are priced out to a specification.

I have not heard that Dr. J. visited Colwyn Bay for the purpose of ascertaining the probable requirements of the town from his experienced standpoint.

Fortunately, however, there are the chairman and several gentlemen of the Colwyn Bay Council who possess a fair and impartial spirit, and they determined to have Mr. Clirehugh and myself up before them, to explain our schemes before finally deciding upon the consulting appointment.

On Tuesday last we duly appeared before the Council. I am glad to say that I prevailed upon the chairman to allow us to be present at the same time, so that the merits and demerits of our individual schemes might be fully discussed, and the difference between £7,450 and £10,500 explained.

If F. & C. scheme was proved to be the better one, I determined to take the beating in good grace.

Mr. Clirehugh was allowed the first shot, and he, in a very able manner, explained the working of his system.

Both systems were of the same nature, viz., three-wire, continuous current, 460 volts between the outers. I give below the comparison :—

Bennett's.	Clirehugh's
Capacity 3,000 *sixteen C.P.* lamps.	Capacity 3,000 *eight C.P.* lamps.
Two 150-H.P. Babcock & Wilcox boilers.	One 120-I.H.P. Babcock & Wilcox boiler.
Two 125-B.H.P. horizontal compound engines.	Three 60-I.H.P. high speed compound vertical engines.
Two 90-unit shunt-wound dynamos.	Three, about 45-unit machines.
Battery 50 amperes, 480 volts, for 7 hours after full charge.	About half this capacity.
Mains 2½ miles, both sides of the road throughout compulsory area.	One side of road only.

The buildings, destructor, and other details, as far as I could see, were much about the same.

Mr. Clirehugh was very loth to have his scheme criticised, stating that he had come there to explain it to the Council; Dr. J. having given him the first award, the time for criticism was passed. The Chairman, however, upheld me, and allowed me to put some very pertinent questions to Mr. Clirehugh, which I must candidly say were not, in my opinion, satisfactorily answered.

The boiler on his plans, or rather those of Messrs. Booth, Chadwick & Porter, was that of the Babcock & Wilcox type; on his estimate £300 was marked against this item; for this price 120 H.P. is the maximum obtainable, therefore I have taken upon myself to judge the H.P. according to the price.

When asking him whether he considered it safe to run public lighting with one boiler only, he *retorted that "boilers very seldom fail*, and he considered that it was amply sufficient, and if it did fail he had his battery to fall back upon." To the questions, "What if it failed during the heavy load? How long would his battery keep up the running," his answer was unintelligible to me.

I again inquired of him whether he or Dr. J. H. would put down a town lighting plant *with only one boiler*, his reply was in the affirmative.

The answer to the question of whether it was desirable or necessary to carry the mains down both sides of the roads was "Certainly not, only on one side." Then I said you would cross the road every time a house or lamp-post on the opposite side wanted to be served? "Yes, certainly."

Mr. Clirehugh further stated, in answer to another question, that instead of appointing a permanent electrical engineer and manager to look after the plant, his scheme recommended the increase of the Surveyor's salary by £120, and he would take over charge. Yet this gentlemen (the Surveyor) could not explain to the Council the great difference between our two schemes, but must write to Dr. J. H. for enlightenment as before-mentioned.

The Council were wise enough to postpone their decision for one month, so that there is yet time for all electrical men who desire fair play in future competitions to speak out through your columns in no uncertain manner.

I am perfectly willing to submit my plans and scheme to you for reproduction, if Messrs. Booth, Chadwick & Porter and Fawcus & Clirehugh will do likewise, for the purpose of comparison.

The chairman and the anti-gas section of the Colwyn Bay Council are only too eager to arrive at the fairest and most equitable decision, as I am sure that they are actuated only by the best and purest motives in their anxiety to serve the ratepayers whom they represent.

Mr. Clirehugh had no adverse criticism to make to my scheme before the Council, and considering that the first award was one giving three schemes equal merit, then preferential consideration ought to have been given to those two schemes that had conformed to the rules of the competition, as they were both ready by January 12th, the advertised limit of terminating the competition, while Messrs. Booth, Chadwick & Porter and Fawcus & Clirehugh, according to the Clerk's statement to me, previously mentioned, did not enter until January 9th, making it impossible to have their schemes in to time; I have also other evidence in support of this. In conclusion, I would like to say that, in my opinion, a 90-unit plant (not duplicated) is altogether inadequate for the lighting of Colwyn Bay. The Promenade, streets and hotels would alone require more than this.

If the other competitors knew that the son of one of the Councillors, and brother to the Town Clerk, was going to compete, do you think that they would have spent the money and trouble to enter the fray? I think not; I know I would not.

I have stated the bare facts of the case in as condensed a form as possible, and hope that the matter may be fully discussed in your valuable paper.

F. F. Bennett.

Manchester, *March 25th*.

Insulated Conduit.

Your correspondent in his letter of March 26th, under the above heading, appears to indulge in witticism and then to lose himself in somewhat involved metaphor, so that it is difficult to discover exactly the ideas meant to be conveyed.

He first makes the statement that "as regards labour and cost of erection, no comparison can be made, because proof cannot be given that better work or worse work is employed," and then a little further on occurs the apparently contradictory statement that the conduit system seems "to be a direct encouragement" to bad work, or as he puts it "to the jerry wireman to put in poor wire and rely on the insulation of his conduit," and concludes his letter with the further statement that "the whole question of the advantage of this system over other systems depends on the class of material and workmanship employed," and not content with this, adds that "all systems are open to the same criticism!" These concluding remarks appear to have been introduced for the sake of leading up to the final question "where then is the advantage of the interior insulated conduit?"

Dealing with this interrogatory, there are one or two points I might briefly refer to :—

The insulating conduit system for which I am contending, assures a very much higher insulation resistance to that of the present methods, the outlet points, joints, &c., being duly provided for by the use of insulated boxes, it being acknowledged that the difficulty of obtaining high I.R. occurs at the outlet points, in fact practical tests show that, inclusive of fittings, a total I.R. of several megohms has been obtained in many of the largest installations.

In respect to security, we have here in England the conditions of a generally humid atmosphere in conjunction with a very large variation of temperature, which surely conduces to "frequent alternations of moisture and dryness."

An insulating tube must minimise the effect of such external changes, for the inorganic bituminous lining is a heat and cold resistant and preserves a more equable temperature to the contained wires.

In respect to economy—and true economy is only secured by the greatest efficiency—the fact is, the cost of the casing or conduit in a high class installation is such a small percentage of the whole outlay, that the total percentage of increased cost does not amount to more than 5 to 10 per cent.

Fred Bathurst.

A Field for Electric Power.

In a lecture given by Prof. Thompson it was pointed out, and rather questioned by a contemporary, that electricity might be expected to provide a means of enabling us to get back in some degree to the state of individualism in many industries. If this be true, electricity will have justified its existence, as it is said there are already far too many human cab horses than there need be. Established systems die hard and slowly, but a return to house production of cloth and the decentralisation of the methods now obtained in our manufacturing districts for the production of cloth, is viewed by some large manufacturers with absolute pleasure. There is at present a knotted counterpane which can only be made by hand and only twenty years ago hundreds of happy people were passing in cloth woven at their own homes.

If, therefore, a means of giving houses about one half a horse power could be devised, there would probably be a return to home weaving.

J. R.

[The field which this peculiarly worded letter suggests has all along been fully recognised by electrical men, together with the difficulties in the way of filling it.—Eds. Elec. Rev.]

Cable Jointing.

Will any of your correspondents be good enough to describe, with sketches, the best method of jointing together two pieces of 19/14 (hard drawn) bare cable? The joint to be in the middle of a 60 foot span, and to be electrically as good a conductor and mechanically as strong before soldering as the remainder of the cable.

Engineer.

Dynamo Fields.

Will you, or any of your readers, be kind enough to give me particulars of the best cast-iron for field magnets of dynamo machines?

I am a foreman of an iron foundry and have to cast small dynamo fields. I cast them of good soft iron with a small amount of aluminium, but I have my doubts about this method. I have also cast them of good ordinary iron, but these fields get fairly warm, which I think is on account of the hardness of the iron, for we have taken particulars of the amount of current that flows through the wires which does not exceed* per square inch of section.

Will you give the brand of iron and the proportion of scrap, or if cast from good pig iron?

S. Barter.

[* Our correspondent does not say how much.—Eds. Elec. Rev.]

Ethics of Modern Science.

A perusal of the recent lecture delivered at the Imperial Institute by Prof. Ayrton, and reported in the *Electrician*, has suggested to me that an essay, having for its title the heading which appears above, might be usefully written, and the only thing that prevents me from undertaking the responsibility of writing such an essay, is that I should have to put aside other and more pressing work.

Charles Kingsley tells us that he found what, in the general acceptance of the term, we understand as history, was one big lie. Now whether he was justified in making so sweeping an assertion I cannot tell, but I do not hesitate to say that it must be a much bigger lie than most of us have been in the habit of regarding it, if it be no more truthful than that which has been given forth from time to time as history of applied science.

In this communication, all that I propose to myself is to make a few somewhat desultory remarks on matters which, in my opinion, are crying out loudly for an expression of public opinion, and I also purpose making a brief reference to the contributions to the solution of the problems of submarine telegraphy contained in my papers on the "Electrical Qualifications requisite in long Submarine Cables," and the "Practical bearing of the Theory of Electricity to Long Submarine Telegraphy," read before the Institution of Civil Engineers, and the Society of Arts, in the years 1858-1859, and published in their *Transactions*, but which are consistently ignored by Prof. Ayrton and his brother partymen, and partly, I am disposed to think, because what is contained in them reflects upon the pretensions of college trained physicists, and is a satire on their claims to be considered electrical authorities, and trustworthy electrical advisers.

There is much that is sad in human life, and there seems to me nothing sadder than the New Testament legend that the one perfect man was taken up into a high mountain, shown the kingdoms of the world and the glory of them, and told that all these things should be given him, if only he would bow down and worship the spirit of evil. We know he resisted the temptation, and we know that his reward was crucifixion.

In the Electrical Review of October 25th, 1889, and following numbers, communications under the heading "Teachers and Students" appear; three of these were written by myself, and two of them by Profs. Ayrton and Perry in the way of reply.

I was provoked to write the first of my communications by a presidential address of Prof. Perry, in which, presumably from a desire to associate the name of Sir William Thomson (Lord Kelvin) with the discovery of the dynamo principle, and at the same time to deprive me of the credit of having made this valuable discovery, he gave utterance to what I described as a "wilful diffusion of error," and the only excuse that he put forward was in effect that his address was drawn up in a hurry. I also expressed the opinion in my first communication that Sir William Thomson had reason for saying "save me from my friends," and I referred to a published statement of Prof. Ayrton in which I said "that the name of Thomson was somewhat unhappily mentioned with the name of Varley."

Clerk Maxwell, it would appear, called attention to the similarity of an influence machine patented by Sir William Thomson in 1865, with an earlier one designed by the late C. F. Varley, and which, as a matter of fact, came under the official notice of Sir William Thomson in 1862. The gist of the extract I made from Ayrton's statement reads as follows:—"Thomson was not even aware that Varley had done anything in the matter, and it was quite to our astonishment, and that of Sir William's, that we came across Varley's patents." A few days after my letter was published, Sir William Thomson (unsolicited) wrote to me calling my attention to two published letters of his which related to that which Maxwell had called attention to, and I found what was contained in these letters was altogether at variance with Prof. Ayrton's version of the matter. So far from expressing ignorance of what Varley had done, he said he remembered Varley's machine very well indeed; but it was different to the machine designed by him.

Prof. Ayrton, as it seems to me, has very unnecessarily compared Lord Kelvin and Sir George Stokes with C. F. Varley, assigning to Varley the second place as an electrician. I think it must be a revelation to Sir George Stokes, and to Lord Kelvin also, to find that they take precedence of C. F. Varley as electricians and telegraph pioneers.

As to what Prof. Ayrton says about Prof. Thomson (Lord Kelvin) doing his best to hammer into dull ears the principles which lay at the root of submarine telegraphy in 1857, it is erroneous on the face of it, and it is also not complimentary to Lord Kelvin; the name of Prof. Thomson has been a tremendous scientific power—certainly from the year 1854, but how much earlier I am not able to say, and he could command a hearing at any time. As a matter of fact, he was invited to join the board of directors of the original Atlantic Telegraph Company in order that they might have the advantage of his scientific knowledge, and he accepted the invitation.

Prof. Ayrton and Prof. Perry have, up to comparatively recently, been scientifically inseparable, and to myself they represent a single individualism. Now, Prof. Ayrton was born in the year 1847 and Prof. Perry in 1850, so it will be seen that in the year 1857 Prof. Ayrton must have reached the very mature age of 10 years and Prof. Perry that of seven, and therefore Prof. Ayrton would seem to consider himself justified in passing judgment on the respective claims of electricians belonging to a period that preceded the electrically bridging the Atlantic Ocean.

Lord Bulwer Lytton tells us "that the alliteration of modesty and merit is pretty enough, but where the merit is great, the veil of that modesty you admire never disguises its contents from its possessor," and this would seem to be the case with the two distinguished pupils of Lord Kelvin, for with what may be described as quite too peculiar Ayrton-Perry modesty, Prof. Perry informs us in the sketch of his life, that Prof. Ayrton and himself "did so much electrical work," that when they left England in 1875 to illumine the Japanese, it was remarked "that the electrical centre of gravity had removed to Japan." I also read in the "Science Retrospect," which appears in the *Times* of January 6th, 1892:—"Prof. Ayrton has been busy during the past year in his investigations into the scientific and practical aspects of electricity—*scarcely* a week passes but he has some *new* problem to bring forward, or a new contrivance to describe."

Profs. Ayrton and Perry, it must be admitted, have had exceptional opportunities and facilities for making scientific advances, but have they, as a matter of fact, ever accomplished work of that description which makes more blades of grass grow where fewer grew before, can they say—*Si monumentum requiris circumspice.*

I have no hesitation in saying that the history of applied science, when truly written, goes to show that mathematical physicists, both of the past and the present, have not proved themselves to be sound enough as electricians to be trustworthy as electrical advisers.

Now, although I have never bowed down before the

"superior wisdom" of those whom Prof. Oliver Lodge has described as "the greater giants of modern times," although I have never accepted the utterances authoritatively thundered forth from time to time, by scientific ecumenical councils, as infallible truths which it is sacrilegious to criticise, and although I am not in the habit of shouting out that it is the voice of God whenever Lord Kelvin speaks, as his courtiers, luminous only by borrowed light, seem never tired of doing, still I have always been able to feel reverence for Lord Kelvin as one on whom a kindly nature has bestowed rare and exceptional gifts.

At the Liverpool meeting of the British Association in 1854 it was my good fortune to come into personal contact with Prof. Thomson (Lord Kelvin), who at that date was an earnest pale-faced young-looking man of 30, who seemed to me to be mortifying the flesh by unduly severe mental work. The reverence with which his special abilities were at that period evidently regarded by mathematicians of an older generation than himself, was to me simply a revelation, and I have a lively remembrance of how shy I felt when we happened to come across one another, and Thomson spoke a few words to me. Perhaps I may be allowed to say that from my early childhood up to the time of Faraday's death I always experienced a certain feeling of awe in the presence of Faraday, and the only other person who has ever inspired in me a similar feeling was Prof. Thomson; and that being so, I feel sure I shall be credited with speaking simple truth when I say that it is painful to me to find myself placed in such a position by Prof. Ayrton, that a sense of duty should compel me to take up a position antagonistic to the claims of Lord Kelvin as an electrician.

I would mention that at the 1854 meeting of the British Association, Foucault delighted the assembled scientists by exhibiting for the first time in this country nearly all of the well-known, but still imperfectly grasped, phenomena of the gyroscope, and with the aid of his very complete and beautifully constructed apparatus, experimentally demonstrating and emphasising all the *now* known scientific data, which form the basis of the gyroscope, and the further developments of it since Foucault's time, made by Lord Kelvin; and yet in Prof. Perry's book on "Spinning Tops," which commences with, and abounds in, fulsome flattery of Lord Kelvin, the name of Foucault in connection with the gyroscope is not so much as mentioned. Surely the pedestal on which Lord Kelvin stands as a physicist is broad enough not to need the pedestals of others. I cannot understand how it is that those who cling to Lord Kelvin's skirts, and lay on flattery with a trowel, are not publicly rebuked.

It is the fate of some of us that circumstances altogether beyond our control create the part we find ourselves *compelled eventually* having to play, providing always that we possess self-respect, and moral grit. By nature I am retiring. I quite recognise that I belong to the past, and if I am not the last survivor of a school of which Faraday was so brilliant an example, and from which all that is sound in telegraphy and electro-dynamics generally has emanated, I seem to be the only living disciple who has the moral courage to fight for its tenets.

Prof. Ayrton would do well to remember that I necessarily know more of early telegraph history than he does, and it would be as well for him to remember also that I do *not* live in a glass house, and that being so, it is very unwise indeed either for him or for any of his brother physicists to force my hand. Prof. Ayrton leaves me only two alternatives, either to allow the credit due to the late C. F. Varley, and to myself also, to be appropriated by others, or to fight.

My own life is a fairly open book. I am, it is true, a few years younger than Lord Kelvin, but I am older as a practical electrician, and my life has been in many respects the very antipodes to that of Lord Kelvin's and to that of the party to which Prof. Ayrton belongs. I am not college trained, but self taught; my lines have not fallen on pleasant places; my road through life has not been made easy for me as has been the case with Lord Kelvin, and also Prof. Ayrton and his colleagues. On the contrary, every difficulty has been placed in my way, and my life, unlike that of the party to which Prof. Ayrton belongs, has been largely one of self-sacrifice; but I can point to original work accomplished of that character which makes more blades of grass grow where fewer existed before. Surely Prof. Ayrton has not altogether forgotten the recent electrical battles in the Law Courts between myself and his colleagues, who did their very best both to deprive me of the scientific credit of having invented "compound winding," and also did their best to obtain a monopoly of it for the Brush Corporation. Surely Prof. Ayrton has not quite forgotten that I was victorious all along the line, and that by substantiating my claim in the Law Courts as the inventor of "compound winding," I was the means of winning an important victory of great pecuniary value to the trade, and one of moral value to myself. Need I remind him that all his friends who had opposed me, when the case came before the Court of Appeal, were censured by Lord McLaren in the following significant words:—"I have difficulty in understanding how it is that a considerable number of able and distinguished men should have been persuaded to give their evidence as to the alleged insufficiency of Mr. Varley's description as an anticipation" of the Brush patent.

With the assistance of Prof. Ayrton's colleagues, assisted by legal Goliaths, the Anglo-Brush Corporation did succeed in overawing the trade, and compelling them to pay royalties on all compound-wound machines that had been made previously to December, 1887, and some months later, and if only they could have obtained a legal title for Lane-Fox's patent No. 3,988—1878, which in 1886-1887 they were interested in, and at the time compound winding was *sub judice*, then for all practical purposes the Brush Corporation would have secured a monopoly of electric lighting by the incandescence system, and if the Lane-Fox patents had only come under the purview of the Law Courts, say, early in 1887, instead of, as it did, in 1892, then I am disposed to believe that Sir Richard Webster would have been able to have added this case to his numerous forensic triumphs in patent litigation. My intervention in December, 1887, however, fell like a bombshell into the camp of those who have Prof. Ayrton's sympathies, and a change came over the spirit of the dream, which I need not refer to beyond saying that the victory won in the compound winding case, had a reflex action on patent No. 3,988—1878, and that it was set aside as unsound by a legal decision delivered March 30th, 1892.

Now, as in the recent past I have been successful over what the world generally, and my friends particularly, regarded as overwhelming odds, I am encouraged to believe that if I only screw my courage to the sticking place, there may be further moral triumphs in store for me, before I pass over to the greater majority.

The late C. F. Varley, in his best days, was certainly the foremost of our telegraph engineers. I have heard him described as the first practical electrician of the world, and I feel very sure that Lord Kelvin would have endorsed this opinion at the time he joined forces with my late brother. No one in the early days of telegraphs did so much for telegraphy as he did; his almost volcanic energy, and intuitive knowledge of electricity, enabled him to bear down opposition and to accomplish much at a time when there was breaking-down work to be done.

In the case of C. F. Varley, and also his brothers, a knowledge of electricity was in no small degree an inheritance; and I have very little doubt that the mathematical faculty so highly developed by Lord Kelvin was in a sense inherited also.

I am very sorry indeed that Prof. Ayrton should have placed me under the necessity of doing anything so invidious as making comparisons; but, happily, I am under no necessity of comparing my late brother and Lord Kelvin with one another as gifted examples of the *genus homo*. C. F. Varley could not hold a candle to Lord Kelvin as a mathematical physicist; but as a specialistic practical electrician he could hold his own—and, I believe, more than his own—against all comers.

The electrical arrangements of the 1865-1866 Atlantic cables stand out in strong contrast to those of the original expedition of 1858; but then C. F. Varley was wholly responsible for them, and also for the specification of the insulated conducting cores.

The scientific advisers of the original Atlantic Telegraph Company were not men of electrical knowledge, they were learned scientists, and they proved to be failures, as the history of applied science shows mere learned *savants* always have been when work of a novel kind has to be performed,

and fresh ground has to be broken. The only persons who came out with any credit in connection with that badly conceived and ill-fated expedition were the mechanical engineers.

I am no partisan of C. F. Varley, but to his credit be it said, he did sound electrical work, and he never played the part of the witches of Macbeth to British investors. Can Prof. Ayrton and his mathematical colleagues say as much?

This communication has already run into such a length, that I must be allowed to continue it in another communication.

S. Alfred Varley.

BUSINESS NOTICES, &c.

Electrical Wares Exported.

Week Ending Mar. 30th, 1896.	£	s.
Adelaide	224	0
Algoa Bay	142	0
Amsterdam	40	0
Bahia. Teleg. mat. ...	910	0
Calcutta	250	0
,, Electric light cable ...	90	0
,, Teleph. mat.	19	0
Cape Town	831	0
Colombo	50	0
Delagoa Bay	60	0
Durban	49	0
East London	242	0
Flushing	10	0
Gandia	90	0
Malta	221	0
Melbourne	115	0
Rosario	17	0
Shanghai	48	0
Sydney	427	0
Yokohama	20	0
Total	£3,855	0

Week Ending Mar. 30th, 1897.	£	s.
Albany	800	0
Amsterdam	800	0
Antwerp	56	0
Auckland	35	0
Bilbao	10	0
Bombay	125	0
Calcutta	176	0
,, Teleg. mat.	36	0
Colombo	85	0
Copenhagen. Teleg. cable	364	0
Delagoa Bay	107	0
Durban	340	0
East London	7	0
,, ,, Teleg. mat.	1,890	0
Flushing	110	0
Hamburg. Teleg. mat.	505	0
Hong Kong	17	0
Madras	171	0
Melbourne. Teleg. mat.	683	0
Ostend	24	0
Otago	27	0
Passages	135	0
Perth	438	0
Port Elizabeth	225	0
Rouen	32	0
Santos	25	0
St. Petersburg. Teleg. material	268	0
Shanghai	157	0
,, Teleph. mat.	35	0
Singapore	43	0
,, Teleph. mat.	234	0
Stockholm	70	0
Sydney	648	0
Trinidad	10	0
Wellington	52	0
Yokohama	60	0
Total	£8,800	0

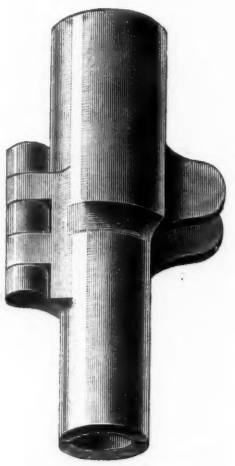
A New Lubricant.—The Emissary electrical lubricant is a semi-solid compound, which is intended for the prevention of friction upon any bearings, by means of the Kingfisher patent lubricator, or other suitable device for supplying it to the rubbing surface. One of its chief applications is on the commutators of electrical machinery for the obviation of wear, friction or sparking. The Emissary lubricant, which is the patent of S. R. Thompson, and for which the sole consignees are the Kingfisher Patent Lubrication Company, of Leeds, is stated to be conducive to more uniform light, steadier running of motors, and to effect economies. A circular before us gives particulars of the other claims which the inventor makes, and also contains results of tests which he has made.

Appointment.—The Edison & Swan United Electric Light Company, Limited, have appointed Mr. J. Lockwood as district superintendent in Manchester, and the business of the company will be carried on from the premises in Victoria Street, previously occupied by the Manchester Edison-Swan Company, now amalgamated with this company. The company have recently issued the lamp and fittings sections of their new catalogue.

Bankruptcy Proceedings.—A receiving order has been made at the London Bankruptcy Court against George Frederick Lee, electrical engineer, 40, Wandsworth Bridge Road, Fulham, lately trading as Lee & Hancock, at 111, Sydney Street, Chelsea. The debtor states that the landlord distrained at Sydney Street for £30 arrears of rent, and sold off everything, including the furniture. He now resides in apartments, and has no assets whatever.

Beecroft & Wightman.—This firm, whose disastrous fire at Bradford we recently recorded, inform us that they have now got machinery running at their mills, and are able to execute orders for electric light casings and covers as usual.

Carbon Adjuster.—Messrs. Rosling & Appleby, of Trafalgar Works, Bradford, are making Gibbings's patent arc lamp carbon adjuster, which we illustrate. By means of this little instrument the carbons of arc lamps may be readily and accurately adjusted, and set in a perfectly true and central position (core to core) when the lamp is being trimmed, thus obviating all the ill effects of side arcs, and the consequent irregularity of burning. Mr. Alfred H. Gibbings, the Bradford borough electrical engineer, is the patentee. Wherever there are a large number of arc lamps belonging to different private concerns, but all supplied from one central station, the chief trouble arises through the inexperience and carelessness of attendants in not properly trimming the lamps in re-carboning them. A very noticeable feature of private arc lamps in any town is the irregular and unsteady manner in which they burn, and in some cases the arc being entirely on one side of the carbons. This defect is the chief cause of fuses blowing, and general dissatisfaction with arc lamps. "Side arcs" are, of course, due to the fact that the original adjustment of the carbons was out of line, and however truly



they may be set by the eye, yet the slightest deviation from the central position at the commencement of burning will become greatly increased as the carbons become shorter, until the points ultimately slide past one another. Absolutely true adjustment is therefore very essential every time the lamps are re-carboned, and it is claimed that this can readily be accomplished by means of the Gibbings "adjuster." It is made in gun-metal.

Change of Address.—The head offices of the I.E.S. Accumulator Company, Limited, have been removed to 78 and 79, Palace Chambers, Bridge Street, Westminster, S.W.

Chloride Electrical Storage Syndicate v. Hurst.—Last week, at the Croydon County Court, before Judge Vernon Lushington, Q.C., this case was heard. It was a claim for £48 16s., for work executed. From what was stated in the course of a long hearing, Mr. Mugford, an electrician, of High Street, South Norwood, fitted the defendant's house up for an electric supply, and the plaintiffs were consulted with reference to the provision of storage batteries, or accumulators, for supplying the current to the lamps. They furnished an estimate, and the work was completed. However, according to defendant, the machinery did not provide sufficient power for the proper illumination of the place.—Judgment for plaintiffs.

Deed of Assignment.—A deed of assignment for the benefit of creditors has been executed by Ernest John Eric, Tomlyn, and William Alfred Gent, trading as Eric Tomlyn & Co., ironmongers, and as Gent & Tomlyn, electrical engineers, Wellington, under which Mr. James H. Hews, ironmonger, Loughborough, is trustee. The unsecured liabilities are returned at £1,035, and the assets, after deducting the claims of preferential creditors payable in full, are estimated to produce £439.

Dissolution of Partnership.—Messrs. A. J. Brooking and E. J. Rigby, carrying on business as electrical engineers and contractors at 14, The Arcade, Exeter, have dissolved partnership by mutual consent as from February 15th. Mr. Brooking will attend to debts.

Electric Bells.—Messrs. D. H. Bonnella & Son, of Mortimer Street, Cavendish Square, W., have issued a new price list of electric bell fittings. There are numerous patterns of pulls, pushes, switches, burglar alarms, trembling and other bells, batteries, indicators, &c., described and illustrated, also a few additional sundries in which the firm trade, including vacuum Geissler tubes, electric jewellery, portable accumulators, speaking tubes, and incandescent lamps.

Fire.—Considerable damage was caused by fire on Tuesday to the manufactory of the United Asbestos Company in West Ferry Road, Millwall.

Electric Traction Materials.—Messrs. Laing, Wharton and Down, Limited, of New Bond Street, W., are giving considerable attention to electric traction, and have issued a 20-page illustrated price list of material for overhead trolley lines. Among the wares described in the pamphlet is the "Medbery" insulation, which is a chemical mixture, moulded whilst in a plastic state under enormous hydraulic pressure, into the required shape. The "Standard," "West End," and "Empire" patterns of line insulators, trolley cars, hangers, and other apparatus are described, also overhead frogs, section insulators, double-pole switches, and sundries.

Electric Lighting Plant.—The question of isolated plants, particularly for country house lighting, is interesting, and judging from the great number of such installations which are in operation in all parts of the country, it is clear that the system is giving satisfaction. This class of work is a speciality of Messrs. Drake and Gorham's, and we recently recorded in our columns that they were at one time busy with as many as 30 country house lighting contracts. Their lengthy and extensive experience has enabled Messrs. Drake and Gorham to acquire a unique understanding of the requirements of private plants, and they have just issued a catalogue of 84 pages bound in stiff green covers, in which they deal specially with the various machinery and accessories, giving the initial outlay necessary in country houses, and also working costs. The minimum dimensions of engine and battery rooms for plants of specified powers are noted. In addition to lump sum estimates, the various plant and accessories are dealt with in detail, including steam, gas, and petroleum engines, boilers, dynamos, D.P. batteries, Nevile automatic accumulator switches, cables and wires, spring contact and other switches, recording and measuring instruments, fittings and accessories. These are all illustrated and priced. Some pages toward the end are devoted to the "Jandus" arc lamp, and instructions for fixing and trimming same are given.

Foreign Trade.—Consul Warburton, in a report to the Foreign Office on the trade, commerce, and navigation of La Rochelle, enters in a very businesslike manner into many important points in connection with the cause of the falling off in British exports to certain parts. His comments do not directly refer to the electrical business, but they are worth reading by every English trader. One of his points to which we would specially draw the attention of electrical people, is the desirability for showing distinctly, when quoting or getting out price lists, the prices for electrical machinery and apparatus delivered in the country of the prospective customer, rather than f.o.b. or f.o.r. London, Liverpool, and so forth. It is easily understood that many of the foreigners with whom we might do very advantageous trade, would not be able to tell what the expenses would be for conveying goods from the home port to their destination. The necessary calculations will sometimes be anything but an easy matter for the manufacturer; but in the majority of cases he is in a better position in this respect than his foreign client, and he would not like to feel that orders were going abroad, say to Germany, because he had left this one stone unturned. A far better plan, wherever possible, is to quote both f.o.b. English port, and free delivery to customers' premises abroad.

Gas.—On 19th ult. a gas explosion occurred at Acfold Road, Fulham, causing fire and personal injury. On 24th ult. a similar occurrence at Mill Street, Driffield, was equally disastrous. Other explosions have occurred at Carisbrooke Road, Newport, and at Greenbank Road, Darlington.

High Voltage Lamps.—Messrs. E. Goosens, Pope & Co., 26, Pall Mall, Liverpool, inform us that they have succeeded in producing a high voltage lamp with single filament, which they will place on the market immediately. They have subjected the lamps to the most rigorous tests both for life and efficiency, and say they can guarantee an efficient life of 1,000 hours. The lamp we have seen is well-made, and is fitted with Pope's patent cap, which entirely obviates the necessity of using plaster of Paris, and contributes to the durability of the lamp in places where changes of temperature are frequent, or in damp situations. We understand that a further improvement in the fitting of the cap is now in hand, and will shortly be announced.

Julius Sax & Co. v. Cooper.—In the Queen's Bench Division of the High Court, on Wednesday, before Mr. Justice Wills, sitting without a jury, this case came on for hearing. The action was brought by plaintiffs, a firm of electrical engineers, to recover from the defendant, a draper at Hackney, charges for fixing an electric light installation at his shops. The defence was a denial that the installation was carried out in a satisfactory manner, or left in perfect working order, which was a condition of the agreement. Mr. S. Edmunds, Q.C., and Mr. Frankau, appeared for the plaintiffs, and Mr. Bousfield, Q.C., and Mr. Walter, for the defendant. Mr. A. G. Siemen, an engineer in the employ of the plaintiffs, said that the work in question was carried out under his direction. A great many alterations were made from time to time at the suggestion of the plaintiffs, and the installation when completed was in perfect working order. Mr. Edmunds observed that his case was that at the time the writ was issued everything was working with perfect satisfaction, but they had at the request of the defendant made many alterations, and added a great number of lamps. If the accumulators were used with the dynamo working at full power, there was an adequate supply of light for all the lamps which could reasonably be in use at the same time. Ultimately, after consultation, it was agreed that the plaintiffs should accept £1,050, without costs, in settlement of all matters in dispute between the parties.

Liquidation Notices.—A general meeting of the Planet Electrical Engineering Company, Limited, will be held at 4, Victoria Mansions, London, on May 3rd, at 10 o'clock a.m., for the purpose of hearing an account by the liquidator (Mr. W. C. Moore) of the winding-up operations.

Creditors of the Thetford Electric Light and Power Company are required to send particulars of their debts or claims to Mr. Lovewell Blake, of Great Yarmouth, the liquidator of the company.

McCrudden v. The Mazarron Electric Light Company, Limited.—This was a claim brought before Mr. Commissioner Kerr at the City of London Court on Tuesday, by Mr. Hugh McCrudden, electrical engineer, 64, Sayer Street, New Kent Road, to recover the sum of £16 13s. 4d. for a month's salary in lieu of notice against the defendants, of Dashwood House, New Broad Street. It appeared that the plaintiff had been in the defendants' service for some time. He was sent out to Barcelona by them to fit up certain electric lighting appliances. Upon his return to this country he was told that his services would not be further required. He asked for a month's notice or a month's wages in lieu thereof, but neither was forthcoming. The defendants' case was that the plaintiff was not entitled to any notice. He gave them a month's notice to leave, but when his notice expired the defendants engaged the plaintiff to go to Spain again to do certain specific work, on the understanding that when he reached London upon his return he was to leave the defendants' service, and not to ask for any notice. The plaintiff denied that, and the case was adjourned for trial before a jury.

Meeting of Creditors.—A meeting of creditors in the Wigston Electrical and Engineering Company, Limited, is to be held on Friday, April 9th, at 3 p.m., at the offices of Messrs. Owston, Dickinson & Simpson, solicitors to the liquidator (Mr. A. B. Wykes), 23, Friar Lane, Leicester.

Motor Cars.—Messrs. New & Mayne, Limited, of Westminster, send us price lists, illustrated in colours, of motor cars as in course of manufacture at their works. One of the lists gives a specification of brake driven by electric motor to cost £450, and the other a specification of a dog cart driven by two-cylinder petroleum engine to cost £250.

New Branch.—Messrs. Street & Co., advertising agents, of 30, Cornhill, E.C., and 5, Serle Street, W.C., announce that in consequence of their increasing business, and for the convenience of their West End clients, they will open on Monday next, April 5th, a branch establishment at 164, Piccadilly, London, W.

Steam Separator.—We have before us a list of the Stemtriff steam dryer and separator, as manufactured by the Empire Company, of Manchester. In this apparatus, it is claimed, there are no mechanical obstructions, as the steam takes a spiral course and the water separates itself from it by being whirled against the sides of the separator, whilst the steam is gradually collected from the centre in a dry state. The list before us gives prices of the separators for steam pipes ranging from 1 inch to 10 inches diameter.

Time Checkers.—A list of automatic time-checking machines has been issued by the Keighley Electrical Engineering Company, Limited, machines for use with metal checks, autograph machines, and electric bell attachments, being described.

The Exchange Telegraph Company, Limited, v. The Central News, Limited.—This was an action brought before Mr. Justice Stirling in the Chancery Division on Wednesday by the plaintiffs, against the Central News, with whom are joined, as defendants, the Column Printing Syndicate (all the parties being distributers of telegraphic news) to restrain the alleged copying by the defendants of racing intelligence from the plaintiffs' tapes. The defence was, shortly, one of denial. Mr. M'Call, Q.C., and Mr. Shearman appeared for the plaintiffs; Mr. Graham Hastings, Q.C., and Mr. Rufus Isaacs for the Central News; and Mr. Macnaghten for the Column Printing Syndicate. The case having been opened, was adjourned.

ELECTRIC LIGHTING NOTES.

Aberdeen.—The Gas and Electric Lighting Committee will recommend the Council to charge consumers of current on a rebate system, and to abolish meter rents from July next.

Bedford.—The report of the Electric Light Committee for the past year shows the profit as £842 7s. 6d. In July, 1895, there were 66 consumers, in December 111; in July, 1896, 170; in December 249, the number of 8-C.P. lamps now in use being 8,550. In July, 1895, there were 3,000. Current has now been supplied for about 15 months; the profits represented 3½ per cent. upon their capital outlay.

Belfast.—Prof. Kennedy is to be asked if he would be prepared to advise the committee as to the engineer's plans and specifications for the proposed new station. The accountant submitted a statement of account of the year's working, showing the net profit on the undertaking to have been £1,553 0s. 6d., without allowing for interest and sinking fund.

Blackheath and Greenwich.—The Lewisham District Board of Works will oppose the application which has been made to the Board of Trade on behalf of the Blackheath and Greenwich District Electric Lighting Company for a provisional order.

Bude and Stratton.—Mr. F. A. Headley, engineer to Messrs. Veale & Co., Limited, St. Austell, has reported on a scheme for lighting Stratton and Bude by electricity. He estimates that Bude will require 40 or 50 public lamps, and Stratton 30; that Bude

will require 1,200 private lamps and Stratton 300 to 400. It is proposed that the system of supply should be by continuous current at a pressure of 240 volts. The estimated cost is about £3,000. The total revenue expected is £780–180 from public and £600 from private lamps. The annual expenses would be about £360. Allowing £150 for depreciation and reserve, there would be £270 for dividend. This result, however, is not contemplated in the first year.

Canterbury.—The Board of Trade have refused to allow the Canterbury Corporation any further extension in connection with their provisional order for electric lighting the city. The order was granted six years ago, and the Board of Trade consider that it is now time some active move was made in the way of carrying out the powers conferred by it, or otherwise the field must be opened out private companies who are willing to take up the matter.

Colwyn Bay.—Last week a meeting of ratepayers was held at Colwyn Bay, under the presidency of Mr. Thomas Parry, chairman of the District Council, for the purpose of deciding upon the advisability (*a*) of purchasing a plot of land for cemetery purposes; (*b*) to establish an electric lighting station in the town; (*c*) to purchase an electric refuse destructor. It was resolved by a large majority to purchase a refuse destructor, the question of site being left open; but a close division ensued on the question of electric lighting, which scheme was rejected by 47 to 46 votes.

Messrs. Clirehugh and Bennett both appeared before the District Council last week, and explained their schemes. In the course of the proceedings the two electrical engineers disagreed upon several points. The Council adjourned the matter until the next meeting.

Cleckheaton.—Some new schools have been erected at a cost of £8,000 in connection with the United Methodist Free Church Central Chapel. They are lighted throughout by electricity.

Douglas.—The Special Committee appointed to report upon the offers of the Douglas Gas Light Company and of the Isle of Man Tramways and Electric Power Company, has asked the Electric Power Company to submit plans showing in detail the whole of their proposed scheme of lighting and overhead tramway traction on the Promenade, so as to give the Council a more complete idea of the general appearance. It is said that the directors of the company intend to suggest to the Town Council that a deputation from their body should accompany some of their own representatives to Bristol for the purpose of viewing the overhead traction system in operation there; and also to Hamburg, where in three streets, very close together, three separate systems of tramways and lighting by electricity are in operation.

Dundee.—For the occasion of a cycle show, the Kinnaird Hall is being fitted up for electric lighting by Messrs. James Maxwell and Son. Six Jandus lamps are to be placed along the centre of the hall, and small incandescent lamps are to be fitted at each of the stalls.

Eastbourne.—The Eastbourne Electric Light Company have ordered a new engine and dynamo capable of supplying 5,000 8-C.P. lamps.

Exeter.—A committee recommends that, with a view to lighting the principal streets of the city by electricity, the Council give notice to the gas company to determine the existing contract for public lighting at Michaelmas next.

Glasgow.—At a recent meeting of the Corporation, the chairman stated that it had come within the knowledge of the Magistrates that in certain buildings which were being erected the wiring for the electric light was being done in a way which, in the opinion of the electrical engineer, was inimical to the safety of the public. The Building Regulations Committee are to frame regulations to remedy such occurrences.

Hastings.—A local paper says that the Corporation will shortly acquire, upon comparatively easy terms, the works and rights of the Electric Light Company.

High Littleton.—A proposition that the parish be lighted electrically was before the annual parish meeting on 26th ult., and the matter deferred for the present.

Hull.—The new applications for current are coming in at a very satisfactory rate. The Electric Light Committee had the question of fire insurance before it the other day, and referred the matter to the chairman (Mr. Skinner), deputy-chairman, and the borough treasurer. Mr. Skinner stated that only one office would insure at a lower rate than at present, and as it was non-tariff they could not recommend it.

Lambeth.—The Vestry has been asked to allow the County of London and Brush Provincial Electric Lighting Company, Limited, to take their mains through the parish, so as to carry current from their Wandsworth station to Camberwell, the roads proposed being Brixton Hill, Upper and Lower Tulse Hill, Trinity Road, Norwood Road, and Thurlow Park Road. Referred to the General Purposes Committee.

Provisional Orders.—The Board of Trade have decided to grant a provisional order to the Corporation of Darwen to supply electricity within their borough, at an expenditure of £20,000. Similar orders have been granted to the Urban District Council of Farnworth, who are authorised to expend £7,300; to the Garston Urban District Council, who are empowered to spend £20,000; to the Urban District Council of Hoylake and West Kirby, who are authorised to spend £10,000; to the Corporation of Wrexham, and to the Urban District Council of Wilmslow, who are empowered to expend £10,000 and £18,415 respectively on electric lighting purposes. These provisional orders will require confirmation by Parliament before they can become operative.

Russia.—The municipal authorities of St. Petersburg are reported to have granted a 40-years concession to the Helios Company, of Ehrenfeld, Cologne, for the supply of electric energy for electric lighting and power purposes in the city.

Southport.—Christ Church, Southport, is lighted by electricity, the installation being carried out by Messrs. Harford and Co. to the specification of Mr. J. Stanley Richmond, consulting engineer. There are, in all, 289 lights. The main fixtures in the body and chancel of the church are combination gas and electric fittings, four having 24 electric and 24 gas lights each, and two having 18 electric and 18 gas lights each. Under and above the galleries are three-light clusters.

Treeton.—Lieut.-Col. Albert C. Smith, R.E., an inspector of the Local Government Board, on 26th ult., held an inquiry at Treeton, near Rotherham, relative to the application by the Parish Council for consent to the borrowing of £600 for the purposes of electric lighting. Treeton is a mining village with a population of 2,000. The necessity had arisen for street lighting, and the Parish Council, after getting estimates, decided in favour of electricity in preference to oil or gas lighting. No opposition was offered.

West Ham.—We learn that at the last meeting of the West Ham Town Council, a letter was read from Mr. E. A. Paris, of the County of London and Brush Provincial Electric Lighting Company, stating that he had been spoken of outside as being one of the persons who were concerned in the charge made by the Electric Construction Company, and he asked the Council to appoint a Special Committee to hear what he had to say on his own behalf. The letter was referred to the Committee appointed in connection with the inquiry. The magisterial inquiry will be opened on Tuesday.

At the last Council meeting, Mr. J. J. Steinitz, the borough electrical engineer, presented a report on the progress of the work. Upon the recommendation of Mr. Steinitz, through a sub-committee, the Council decided to enter into an agreement with the Free Wiring Syndicate, Limited. Although the laying of the mains has commenced, the carrying out of this work will occupy some months, as many miles of cable are to be laid. The cables are being manufactured by the British Insulated Wire Company, and Mr. Steinitz reports that so far they have got 13,260 yards of high tension cable, 7,240 yards of low tension cable, and 7,040 yards of arc lighting cable ready. The Council have decided upon arc lamps for street lighting purposes.

West Australia.—According to a Sydney paper, the Kalgoorlie Town Council has accepted the offer of Messrs. Sedgwick, Limited, to erect and hand over in running order a plant for £7,500. This will provide for four arc lamps of 2,000 C.P. each for street lighting, and a number of incandescent lamps of 16 C.P. for general use. The work of installation will be commenced immediately.

Wimbledon.—The Board of Trade has granted to the District Council a provisional order for electric lighting. The scheme proposed puts the cost at £32,000.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Behr's Lightning Express.—On Friday last week a number of engineers and Gloucester citizens visited the works of the Gloucester Railway Waggon & Carriage Co. and there inspected Mr. F. B. Behr's "lightning express" electric railway system.

Birmingham, Wolverhampton, and District.—The British Electric Traction Company, Limited, has addressed the following letter on the above subject to the various local authorities interested:—"With reference to the negotiations which we have conducted during the past 12 months with the local authorities concerned, we think it well to inform you as to the present position of the matter. Some of the Corporations were prepared to give their consent to our Bill, but in the case of others, the consent was made conditional upon our entering into agreements for the purchase of electrical current, and other matters as to which it has proved impossible to agree to such terms as are compatible with the commercial success of the scheme. As we have not, therefore, been able to comply with Standing Orders, there has been no alternative but to withdraw the Bill. We very much regret that we have been compelled to take this course, recognising, as we do, the disappointment which it will cause to the inhabitants of the various districts, who are desirous of obtaining the greater facilities of communication we are prepared to provide. Having regard, however, to the considerable time and attention we have already devoted to this scheme, it is not our intention to abandon its main features, and we propose to resume negotiations with the various authorities and companies with a view to carrying out a scheme of consolidating and extending various tramway undertakings in the district, and of adapting the same for electrical working."

Brighton-Rottingdean.—The repairs to the sea-going car used on the Brighton and Rottingdean Electric Railway, which suffered so severely during the great storm, are well in hand, and the most strenuous efforts are being made to reopen the line shortly after Easter. The car was not nearly so seriously injured as was at first supposed. In reconstructing it extra machinery has been provided and additional wheels connected.

Broadstairs.—A number of St. Peter's and Broadstairs ratepayers have petitioned the District Council opposing the suggested electric passenger tramway in the districts. The Council will consider the matter in special meeting.

Coventry. — The Coventry Electric Tramways Bill (extensions) being unopposed, has been referred back to the Committee on Unopposed Bills.

Dutch East Indies.—A company has just been formed in Amsterdam with a capital of 1,600,000 florins to be known as the Batavia Electric Tramway Company. The new company takes over a concession for the construction and working of three lines of electric tramways in Batavia. The contract for the construction of the lines and the supply of the necessary plant has been placed with the Union Electrical Company of Berlin.

Dublin.—The Clontarf Commissioners have sanctioned the commencing of the laying of the electric cables, erection of posts, &c., subject to the approval of the township surveyor, in connection with the new electric tram service from Annesley Bridge to Dollymount. The poles are being erected.

The Commissioners of Public Works, in Ireland, appointed J. H. Ryan, Esquire, civil engineer, to make the necessary inquiry, from an engineering point of view, into the proposed Clontarf and Hill of Howth Tramway, on Saturday last.

Plans for extension of the electric trams in Dalkey were laid on the table at a recent meeting of the Dalkey Commissioners and referred to the engineer for report.

The question whether the Tramways Company may subject to the approval of the Borough Surveyor, introduce electric traction into the city thoroughfares, was before the North City Ward Ratepayers Association on Monday.

Electric Locomotives in Belgium. — The Belgian Government have (the London correspondent of the *Glasgow Herald* hears) decided upon a trial of electric locomotives on the ordinary State railways, starting with the nine mile run between Brussels and Tervueren. No conductors are to be used, the electric cars taking their place in the ordinary train. The Belgians are adopting the accumulator system, notwithstanding its weight, so that the financial results will be valuable for comparison. The speed is to be 31 miles, reduced to 18½ miles an hour on the steepest gradients.

Leeds.—It is interesting to note that some Leeds workmen, who were digging at a depth of about 5 feet in connection with the laying down of the underground wires for the electric tramways, came across a seam of coal 18 inches thick, at Briggate on Monday last.

Motor Cars at Brighton.—Application has been made to the Watch Committee of the Brighton Town Council for permission to run an electric char-a-banc from Brighton to places of interest in the surrounding districts. The committee have resolved that they will be willing to grant licenses for electric motor char-a-bancs after each vehicle has been inspected and approved by the committee.

The Underground Railway Schemes.—The Select Committee of the House of Commons, appointed to enquire into the merits of the Brompton and Piccadilly Railway scheme, concluded last week the hearing of the evidence which has been offered in support of and in opposition to the railway. Prof. A. B. W. Kennedy, electrical engineer to the company, gave evidence, and stated that the site of the generating station at Chelsea Creek, some distance from the terminus of the line, was very advantageous because of the facilities it afforded for obtaining water for condensation, and because coal could be obtained there at about 2s. 6d. a ton cheaper than in town. Being some hundreds of yards from the river, it was not likely to interfere with embankment improvements or extensions. The communication from the generating station to the railway would be by two concentric cables, each containing a go and return conductor, the whole being covered outside with an armour of steel to protect it from mechanical injury. The working of the railway would require a maximum of about 1,200 horse-power. The current required, generated at a pressure of from 1,100 to 1,200 volts, would be transmitted direct to the terminus at Brompton, where it would be divided so that there would be a pressure of from 500 to 600 volts for each tunnel. At present it was proposed to run trains of three coaches, possibly four, each coach to contain about 50 persons; and though it had not been finally settled, there would probably be only one class. The Committee decided to defer any decision on the Bill until after they had heard the evidence in the City and West End Railway Bill. Evidence in support of this Bill was given in the afternoon by Sir Benjamin Baker, C.E., the engineer to the scheme. He said that the stations were to be at Hammersmith Broadway, Addison Road, Earl's Court Road, Kensington Church, the Albert Hall, Knightsbridge, Hyde Park Corner, St. James's, Piccadilly Circus, Trafalgar Square, Wellington Street, the Law Courts, Ludgate Circus, and Cannon Street. The shortest distance between two stations was 524 yards, which was the case in the City, and the greatest distance twice that length, which was the case at St. James's. In every instance the stations fronted directly on to the great thoroughfares, which was most important, as some of the existing lines had found to their cost, especially in regard to the Edgware Road Station. The greatest depth of the line was at Piccadilly Circus, where it was taken down to pass under the Waterloo and Baker Street line, which ran at right angles to it there. Interchange between the two lines at that point would be by means of an iron subway and galleries. There would be similar connection with the Charing Cross and Hampstead line at Charing Cross. Just past each station the line would suddenly dip about 1 in 30, the effect of which would be to enable the train to attain a high speed quickly and to travel over the whole line at a speed, including stoppages, of about 14 miles an hour. The estimated cost of £2,880,000 was based on the estimates in the case of the Central London Railway, £60,000 per mile being allowed for the cost of property along the proposed route in excess of that cost on the Oxford Street line. A margin of £70,000 for contingencies was allowed, and in this connection he complained of the unreliability of workmen and of the difficulty in dealing with them. Where a gang used to do 60 feet of tunnel a week, they had been told they must not now do more than 40. Other similar changes might take place, and thus the large margin was required for safety. While each train would contain about 400 passengers, the rival line only provided for about 150 per train. The rolling stock would be altogether heavier than on the Piccadilly and Brompton line, an electric locomotive of 500 horse-power being used for each train in place of the electric cabs proposed on that line. Making allowance for the extra cost of property, the estimate per mile on the proposed line and on the Central London were about the same. He did not anticipate any difficulty in the construction of this line from an engineering point of view. There would be no danger from vibration, or injury to property from the making of the line; and the opposition in this respect had almost entirely disappeared. There was to be a subway costing £12,000 or £15,000 from the Strand Station to the Outer Temple buildings, but that would be closed when the Courts were closed. He could not undertake to extend the subway under the Strand at the expense of the company.

Torquay-Paignton.—Mr. J. C. Wharton in delivering locally a lecture on "Electricity," took the opportunity of bringing the merits of the proposed electric tramway system, for which he is the engineer, before the residents.

The Torquay Council on Monday discussed the electric tram scheme with the engineer, Mr. Wharton, but no vote was taken. When it was proposed to discuss the subject in committee, Dr. Richardson and others objected, but without success. Dr. Richardson then left the meeting, declaring he was strongly opposed to the scheme, and that nothing would convince him in its favour. The road was too narrow, and would be seriously injured by such a line. The scheme will come before the Council again next Tuesday.

TELEGRAPH AND TELEPHONE NOTES.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired.
Brest-St. Pierre (Anglo, 1869)	April 6th, 1895 ...	...
West Indies—		
Puerto Plata-Martinique	Dec. 19th, 1895 ...	...
St. Croix-Trinidad ...	Nov. 30th, 1896 ...	...
Jamaica-Colon	Feb. 6th, 1897 ...	...
Amazon Company's cable—		
Parintins-Itacatiara ...	May 5th, 1896 ...	...
Obidos-Parintins ...	Dec. 7th, 1896 ...	...
Assab-Massowah	Feb. 20th, 1897 ...	March 25th, 1897.
Tenedos-Dardanelles ...	March 23rd, 1897 ...	March 29th, 1897.
Malta-Alexandria	March 23rd, 1897 ...	March 29th, 1897.
Emden-Vigo	March 24th, 1897 ...	...
Landlines.		
Trans-Continental line beyond Mazol	March 12th, 1896 ...	...
Carthagena - Barranquilla (Columbia)	July 4th, 1896 ...	...
Mexican landlines beyond San Juan Bautista	March 26th, 1897 ...	March 28th, 1897.
(Telegrams for Yucatan subject to delay.)		
Saigon-Bangkok	March 27th, 1897 ...	March 28th, 1897.
	March 31st, 1897 ...	March 31st, 1897.

Note.

March 26th.—The Eastern Telegraph Company notify delay on messages for Egypt.

March 31st.—The *Daily Telegraph* publishes Cape telegrams of 29th inst. as delayed in transmission.

Liverpool.—The Sailor's Home has just been fitted with a very complete installation of telephonic intercommunication, the work having been carried out by Messrs. Harford & Co.

Manchester Telephones.—The movement here in favour of a competitive telephone system to be put down by the New Mutual Telephone Syndicate is still progressing.

New Cable.—The new cable between India and Ceylon was to be laid last month, the cable steamer *Patrick Stewart*, belonging to the Indo-European Telegraph Department, being requisitioned for the work.

The Telephone in West Scotland.—An inquiry has been ordered by the Postmaster-General regarding the telephonic communication in part of the west of Scotland. For a considerable time there have been serious complaints of delays and defective service between Glasgow and the east, Stirlingshire, and the Airdrie districts of Lanarkshire.

The Tweedmouth's Report. — The telegraphists of Liverpool, Edinburgh, and various other centres have been meeting together to discuss the report of the Tweedmouth Committee, to which we referred in our leader last week, and to ventilate their feelings of dissatisfaction regarding same.

Vive La France.—The construction of the new French Atlantic cable to be laid under contract with the French Government between Brest and New York is, says the *Journal des Postes*, being actively carried on at the works at Bezons, and the wire there manufactured is transferred to Calais to be used for sheathing purposes. The following figures, which, by the way, we noted some weeks ago show the importance of this work now being accomplished in France. The length of the new cable will be at least 3,250 nautical miles, the longest cable at present laid. The conductor will absorb 975,000 kilos of copper, and the gutta-percha 845,000 kilos. Galvanised iron wire 4,687,000 kilos, and for the heavy cables 1,495,000 kilos. The whole weight of the cable will be 10,976,350 kilos. It is said by the journal that no less than four large cable steamers will be required to carry out the work to be done during the coming summer.

CONTRACTS OPEN AND CLOSED.

OPEN.

Bray.—April 5th. The Commissioners are prepared to consider tenders for an extension to the switchboard at the electricity works.

Brighton.—April 12th. Tenders are wanted for the supply and delivery of armoured lead covered electric cables and jointing sundries.

Bristol.—April 7th. The Electrical Committee invite tenders for the supply and erection of condensing plant, steam and exhaust piping, &c. Electrical Engineer, Mr. H. Faraday Proctor.

Cardiff.—The Corporation want tenders for the supply and laying of high and low pressure compound concentric cable and sundry transformers. Electrical Engineer, Mr. N. Appelbee. See our "Official Notices."

Edinburgh. — April 6th. In connection with the conversion of their tramways to cable traction the Corporation invite tenders for the supply of boilers, superheaters, mechanical stokers, fuel economisers, &c. Particulars from Mr. N. Colam, 1, Parliament Square, Edinburgh.

Edinburgh.—April 10th. The Corporation want tenders for the supply of good steam coal for the electricity supply station from May, 1897, to May, 1898. Specification, &c., from the Resident Electrical Engineer, 5, Dewar Place.

Hull.—April 8th. The Electric Lighting Committee want tenders for the following in connection with the electricity supply extensions, Borough Electrical Engineer, Mr. A. S. Barnard:—Boilers, economiser, crane, engines, condensers, pumps, dynamos, transformers, switchboards, batteries, mains, &c.

Jamaica.—April 15th. The Privy Council invites applications for a license for the establishment and working of a system of rapid transit in Kingston and environs. Copies of the Tramways Law, 1895, and of local rules and maps of Kingston and environs may be seen at the offices of the Crown Agents for the Colonies, London.

Luxembourg.—April 11th. Tenders are being invited by the Luxembourg Post and Telegraph Department for the supply of 40 tons of galvanised iron wire, 3,000 metres of insulated wire, 1 ton of bronze wire, and 1,500 porcelain insulators, &c. Tenders to La Direction des Postes et des Telegraphes, Luxembourg.

Manchester.—April 5th. The Lancashire and Yorkshire Railway Company are inviting tenders for the supply of various articles during the twelve months ended April 30th, 1898, including signal and telegraph fittings; signal, telegraph and electric light wires; wire, steel tubes for boilers, &c. Particulars from the Stores Department, Osborne Street, Manchester.

Portsmouth. — April 2nd. The Corporation wants tenders for the supply and erection of three motor generators and switchboard arrangements, also a battery of accumulators with stands. Engineers, Messrs. Kincaid, Waller & Manville.

Roumania.—April 19th. The General Direction of the Roumanian Posts and Telegraphs in Bucharest is inviting tenders until April 19th for the supply of 55½ tons of iron wire.

St. Pancras.—April 27th. The St. Pancras Vestry want tenders for the wiring, &c., in connection with the electric lighting of the Whitfield Street Baths and Washhouses. See our "Official Notices."

CLOSED.

Paisley.—At a meeting of the Council held on Monday, 29th ult., the following tenders were accepted in connection with the electricity works:—Messrs. S. Z. de Ferranti, Limited, 3 steam alternators (two 200 kilowatts and one 100 kilowatts), main switch gear, three rectifiers and switch gear, and transformers, £10,603 10s.; Messrs. Babcock & Wilcox, Limited, 3 steam boilers, Vicar's mechanical stokers, and Green's economiser, £2,415; Messrs. Callender's Cable & Construction Company, Limited, high and low tension and arc lighting mains, £6,154. There are several sections of the scheme yet to be dealt with.

NOTES.

Lord Rayleigh's Fourth Lecture.—Last Saturday, in the course of the fourth of his series of lectures at the Royal Institution on "Electricity and Electrical Vibrations," Lord Rayleigh said he had purposely refrained from discussing the practical construction of transformers depending on the principles which he had referred to, because there were other matters upon which he could better employ the time at his disposal. He pointed out, however, according to the *Times* report, that all the difficulties in the design of transformers arose from the fact that in their construction only a material of finite conductivity could be employed. With a material of infinite conductivity, design would become a very simple matter, and the whole theory of transformers might be disposed of in a few lines. No iron, which was a great source of complications, would be wanted, and the transformers need not be very large, because the smallest would be capable of doing any amount of work. Lord Rayleigh then gave one or two additional illustrations of the use of the telephone and sensitive flame in induction problems, and performed an experiment which was remarkable for the paradoxical character of the conclusion to be drawn from it. A circuit carrying an induced current was made to branch into two parts, one of which passed through one wire of a coil carrying three windings, while the other passed through the other two wires of the same coil. Owing to mutual induction and self-induction, the telephone showed that the current in one of the branches was greater than that in the main before it separated into two parts. So far Lord Rayleigh, in these telephone experiments, had been dealing with vibrations whose frequency was mainly determined by the ear, and was in the neighbourhood of 1,000 a second. He now turned to the currents of still higher frequency, obtained by the discharge of a Leyden jar. The frequency depended on circumstances, but 1,000,000 a second was not out of the way, and 10,000,000 might be reached. For purposes of experimental investigation, it was desirable to have some means of slowing down these vibrations, and this might be done by using a source of electricity of large capacity, and making the discharge pass through a coil with great self-induction. This was equivalent to increasing the inertia of a mechanical system. The interposition of the coil reduced the frequency of the vibrations to perhaps 1,000 a second, and its effect was apparent by the changed character of the spark, the snapping noise of which was exchanged for a sound possessing a more definite musical character. In conclusion, Lord Rayleigh showed some experiments with the currents produced, according to Mr. Tesla's methods, by using the discharge of a battery of Leyden jars to excite a special oil-insulated transformer, and explained the effects as mainly due to the exceedingly high frequency of the currents. He contended, for the appropriateness of the term "high frequency" in this case, on the ground that, though there were intervals in which no current was passing, when the current was passing it consisted of extremely rapid vibrations.

Personal. — Mr. Claude W. Hill has been appointed general manager to the Phœnix Dynamo Manufacturing Company, of Bradford.

Mr. S. Y. Shoubridge, who is leaving the Salford Corporation gasworks to take up the duties of engineer to the Crystal Palace Gas Company, in addition to his duties as gas engineer, also superintended the construction of the Salford electric lighting station, in conjunction with the consulting electricians engaged by the Corporation, and we understand that since it was opened he has had the management of it.

Lectures.—A lecture on "Prof. Rontgen's 'X' Rays; their Origin, Use, and Possibilities," was delivered on Wednesday evening at the Offord Road Chapel, Barnsbury, by Mr. Wm. H. Marshall. The chair was taken by the Hon. W. H. Massey-Mainwaring, M.P., LL.B.

On Monday last week, at the Royal Institution, Swansea, Dr. F. Knight delivered a lecture on "Electricity as Applied to Medicine."

Mr. Reg. Wallis-Jones lectured in the Trades Hall, Glasgow, on "Electrical Traction as Applied to Tramways," on Monday, his remarks being illustrated by limelight views.

The Charters Towers Installation.—In our "Electric Lighting Note" regarding the new plant which has been put down at Charters Towers, we omitted to say last week that Mr. Erskine (of Messrs. Crompton & Co.) was the executive engineer in connection with the whole work.

Obituary.—We note with regret that Mr. F. W. Crossley, who with his brother has carried on the manufacture of the well known Otto gas engines at Manchester, under the style of Crossley Bros., died on Thursday last week, at the age of 57.

The Institution of Electrical Engineers.—On Thursday, April 8th, 1897, a paper on "Recent Developments in Electric Traction Appliances" will be read by H. A. Baylor.

Electric Hansom Cabs.—As we go to press, Messrs. Shippey Bros. write to us as follows:—"We have read your description of the Morris-Salom electric hansom, which appeared in last week's issue, with considerable interest; more so, as we are the firm who first introduced the 'Lundell system' into this country, as agents of the Interior Conduit and Insulation Company, of New York. We have sold some hundreds of them in all sizes during the past four years, and we do not remember ever having had any real complaints. The Lundell motor is undoubtedly a good one for power purposes, and has several good points, and as Messrs. Holmes and Co. will, at an early date, make them in England, we may consider that the system has come to stay. At the same time we are bound to say for this work it is not so good as the 'Riker Motor' for electric hansoms, horseless carriages, and ladies' motorette vehicles. Now, as we are agents for both systems, we are quite impartial in stating these facts, as it does not matter to us at present which type of motor we sell, as we get the same profit out of the one as the other. However, our object in writing this letter is more to correct an error which has crept into your Journal through the report published in the *Scientific American* respecting the Providence race, because, in this report, it is made to appear that the Morris-Salom system won the race at Providence. This is really not so, as the winning car was the Riker system, as correctly stated by you in a previous issue of the REVIEW, published on December 11th, 1896, and recorded on page 771. Knowing that the REVIEW prides itself on recording correct information, we hasten to correct this little mistake in the interests of the Riker system, now controlled by our firm. We note what an enormous weight of batteries the Morris-Salom people are compelled to use for an 18-mile run, while by the Woodward-Riker combination of battery and motor less than one-half this dead weight is used for much longer runs. We think some particulars of the merits relative to the latter system may interest your readers, and although we have not time this week to send particulars, we will do so in the near future, as it may interest English carriage builders, and enable them to develop the 'horseless carriage industry' without being forced to pay large royalties for a something not included in the supposed monopoly relative to the above subject."

Pleasant Reading.—We cull the following from the *Review of the River Plate* for March 6th:—

> We have much pleasure in congratulating our contemporary, the ELECTRICAL REVIEW, of London, on the occasion of its reaching its thousand and first number. The paper was first started as a monthly in 1872, a bi-monthly in 1873, and a weekly in 1882. It was the first electrical journal published in England, and those of the profession who have done pioneer work in semi-civilised countries will evidently recall with pleasure those days when the paper did arrive, and they were enabled to keep in touch with what was going on in the electrical world from which they were shut off by thousands of miles. The writer in this instance does, and there are many more who, we are sure, will unite with us in wishing the ELECTRICAL REVIEW continued prosperity.

We offer the writer, whoever he may be, our best thanks for his kindly sentiments.

The Institution of Mechanical Engineers.—It is announced that, in order to meet the convenience of H.R.H. the Duke of Cambridge, who is to be the guest of the evening on the occasion of the Jubilee dinner of the Institution, of which His Royal Highness is an honorary member, the date has been altered from Wednesday, April 28th, to the following day. The dinner will take place at the Hotel Cecil, under the presidency of Mr. E. Windsor Richards.

Trade with Australia.—An Australian correspondent sends us a somewhat lengthy letter, asking us to draw the attention of English manufacturers of electrical apparatus and supplies to the fact that German competition is showing itself somewhat forcibly in those parts just now. We referred not long ago to the speed with which German makers executed orders as compared with the tardy methods of some English houses. Our correspondent, who, we think, exaggerates the state of affairs rather considerably, does not suggest any special means for meeting the competition, excepting that English houses should "enliven" their agents, and keep them posted with samples of their wares.

Electricity in Mining.—Before the Midland Institute of Mining Engineers at Barnsley on 27th ult., Messrs. H. St. John Durnford and R. Holiday read a joint paper on the "Use of Electricity at Ackton Fall Collieries." It was explained that electricity is used for various purposes at the mines, 12 motors being at work on the surface and in the pit. The authors believed the employment of electric power had resulted in great saving of expense, and increased efficiency.

X Rays.—At the Camera Club on the evening of April 12th, Mr. A. A. C. Swinton will give a paper on "Recent Investigations Relating to X Rays." The paper will be illustrated by original experiments, and a new form of improved adjustable Crookes tube for practical X ray work, designed by Mr. Swinton, will also be shown, with which the penetrative quality of the X rays can be varied at will.

Horseless Cabs in New York.—Last night's paper stated that a large number of mechanically propelled hansom cabs made their appearance in New York on Wednesday for hire. They have been appointed regular stands, and have been doing good business. The public seem to look upon them with favour. The charges are the same as those made for hansoms drawn by horses.

The Presidency of the Chemical Society.—The annual meeting of the Chemical Society was held on Wednesday afternoon in the rooms of the Society in Burlington House. For the first time in the history of the Society there were two rival candidates for the presidential chair—Prof. Dewar and Prof. Ramsay. The first-named was nominated by the Council, and the choice of this body has, up till now, never been called in question. This year, however, says the *Pall Mall Gazette*, some of the younger fellows revolted and determined to push a candidate of their own. The result of the ballot was that Prof. Dewar was elected president by a substantial majority. A very large number of fellows went to Burlington House to record their votes, and the greatest excitement prevailed. Owing to the inaccuracy of information received yesterday afternoon, Prof. Ramsay was wrongly announced as having been elected.

Appointment Vacant.—The St. Pancras Vestry give notice that the date for sending in applications for the post of distributing engineer has been extended to April 13th. See our "Official Notices."

For the Rand.—We hear that Mr. Gabriel Andreoli sails to-morrow (Saturday) on board the *Tantallon Castle* for South Africa. He has been engaged by Mr. Charles Butters on behalf of the Rand Central Ore Reduction Company. When electro-chemists are wanted for the goldfields, it would hardly appear that electrolysis has been abandoned!

The West Ham Scandal.—From our "Official Notices" it will be observed that Mr. Baggallay, the stipendiary magistrate for West Ham, will hold an inquiry at the Town Hall on Tuesday, April 6th, into the electric lighting contracts scandal.

Society of Arts.—On Monday next, April 5th, at 4.30 p.m., Prof. W. Chandler Roberts-Austen, C.B., F.R.S., will deliver the last of his series of Cantor lectures on "Alloys." He will deal with advances in our knowledge of alloys since the last course of Cantor lectures "On Alloys" was delivered in 1893.

NEW COMPANIES REGISTERED.

British Electrical Cycle and Motor Engineering Company, Limited (51,815).—Registered March 26th with capital £40,000, in £5 shares (4,000 £7 per cent. cumulative preference), and to carry on the business of manufacturers of electrical generators, motors, or accumulators, lamps, carbons, engines, &c., also motor and motor car manufacturers, India-rubber manufacturers, engineers, founders, smiths, &c. The subscribers (with one share each) are: G. V. Corry, 17, Upper Baker Street, W., director of company; P. Capps, 268, Cornwall Road, Notting Hill, clerk; J. Fletcher, 9, Ladbroke Crescent, North Kensington, traveller; C. G. Garner, 23, Oxford Street, Stepney, clerk; E. Coward, 2, King Street, Tower, clerk; E. A. Lockner, 40, Newton Road, Westbourne Grove, clerk; H. Drake, 9, Station Road, Shepherd's Bush, accountant. The number of directors is not to be less than two, nor more than seven. The subscribers are to appoint the first; qualification, 20 shares; remuneration, one guinea each per board meeting attended. Registered office, 75, Finsbury Pavement, E.C.

New Fowler-Lancaster, Limited (51,824).—Registered March 26th, with capital £100,000 in £1 shares, to acquire the business carried on in Birmingham and elsewhere by Fowler-Lancaster and Co., Limited, and to carry on the business of electrical, cycle and mechanical engineers, contractors, and manufacturers. The subscribers (with one share each) are:—S. G. Moore, Buckingham Street Works, Birmingham, manufacturer; W. Prest, Wake Green House, Moseley, Birmingham, manufacturer; G. N. Fowler, Longbridge, Warwick, engineer; E. W. Lancaster, Church Road, Molesey, engineer; T. D. Neal, 39, Newhall Street, Birmingham, chartered accountant; J. Pitt, 39, Newhall Street, Birmingham, accountant; L. N. Heeley, 5, Station Road, Edgbaston, Birmingham, chartered accountant; R. H. Turner, 37, Carlyle Road, Handsworth, cashier. The number of directors is not to be less than two nor more than six; the subscribers are to appoint the first; qualification, 250 shares; remuneration, £500 per annum divisible, and a percentage of the profits. Registered by Huxham & Rawlinson, 42, Bedford Row, W.C.

Folkestone Electricity Supply Company, Limited (51,825).—Registered March 26th with capital £50,000, in £5 shares, to adopt an agreement with the Mayor, aldermen and burgesses of Folkestone, to take over the Folkestone Electric Lighting Order, 1896, and to carry on the business of suppliers of electricity, electricians, electrical engineers, apparatus manufacturers, &c. The subscribers (with one share each) are:—W. B. Hopkins, 30, Parliament Street, S.W., civil engineer; G. Spurgen, Waynflete, Folkestone, gentleman; S. Penfold, 70, Cheriton Road, Folkestone, wine merchant; D. Baker, Westbourne Gardens, Folkestone, builder; C. J. Pursey, 99, Dover Road, outfitter; G. I. Swoffer, Morehall, Folkestone, merchant; H. Brooke, 9, Millfield, Folkestone, wine merchant. The number of directors is not to be less than five, nor more than eight; the first are the first five subscribers; qualification £250; remuneration £500 per annum divisible. Registered by Collyer, Bristow and Co., 4, Bedford Row, W.C.

Electric Metal Working Syndicate, Limited (51,826).—Registered March 26th with capital £40,000 in £1 shares, to adopt an agreement with G. W. de Tunzelmann, commercially develop and obtain contracts for the supply, sale or lease, on royalty, of electric welding apparatus, and to carry on the business of engineers, light and power contractors, electricians, electrical manufacturers, and makers of dynamos, motors, &c. The subscribers (with one share each) are:—G. W. de Tunzelmann, 2, Penywern Road, S.W., electrical engineer; C. E. Cree, 12, Nevern Road, S.W., barrister; C. A. A. Capito, Rushbourne, Ramsgate, civil engineer; F. M. Eden, 63, Warwick Road, S.W., barrister; R. R. Corkling, 8, Almater Road, Kensington, lecturer; H. I. Norballe, 33, Kempsford Gardens, S.W., engineer; C. W. Baker, Yew Grove, Crickwood, N.W., electrical engineer. The number of directors is not to be less than three nor more than five; the first are—F. M. Eden, G. W. de Tunzelmann, R. B. Broxby, and Captain E. Robinson; qualification £100; remuneration £150 each per annum, and £200 for the chairman. Registered office, 61, Gracechurch Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Fleetwood and District Electric Light and Power Syndicate, Limited (49,666).—This company's statutory return, filed on March 2nd, shows that seven shares have been taken up out of a capital of £20,005 in £1 shares, and paid for in full.

Europe and Azores Telegraph Company, Limited (39,452).—This company's annual return was filed on February 4th, when 16,704 shares were taken up out of a capital of £200,000 in £10 shares; 5,568 of these are considered as paid, and £10 per share has been called and paid on the remaining 11,136 shares.

Guildford Electricity Supply Company, Limited (36,725).—This company's annual return was filed on January 6th. The capital is £20,000, in 3,900 ordinary shares of £5 each, and 500 founders' shares of £1 each. 1,364 ordinary and 500 founders' shares have been taken up, and the full amount has been called; £6,652 has been paid, and £668 has yet to come in.

General Electric Company, Limited (29,433).—This company's annual return has just been filed. The capital is £200,000 in 7,000 first preference, 1,000 second preference, 5,000 third preference, and 27,000 ordinary shares of £5 each; 17,000 of these have been taken up, and 1,000 second preference and 4,000 ordinary are considered as paid. £5 per share has been called on 10,800, £3 10s. per share on 600, and £2 10s. on 600, and the total of £56,700 has been paid.

Kensington and Knightsbridge Electric Lighting Company, Limited (26,193).—This company's annual return was filed on March 15th. The capital is £350,000, in 50,000 ordinary, 10,000 first preference, and 10,000 second preference shares of £5 each; 15,000 ordinary, 10,000 first preference, and 3,500 second preference have been taken up, and 5,000 ordinary are considered as paid. £5 per share has been called on the others, and £117,500 has been paid.

CITY NOTES.

The Metropolitan Electric Supply Company, Limited.

The tenth ordinary general meeting of the shareholders of this company was held on Monday last at the Portman Rooms, Baker Street, under the presidency of Sir Eyre M. Shaw, K.C.B., the chairman.

Mr. E. Cunliffe Owen, C.M.G. (the secretary), having read the advertisement convening the meeting, the report was taken as read.

The Chairman, in proposing the adoption of the report, referred at length to the changes that had become necessary on the board. They had elected Mr. Frank Bailey to a seat on the board as engineering director. Mr. Bailey's connection with the company had been a long and honourable one, and in thus securing his closer identification with the company, they believed they had taken a wise and prudent step. The chairman continued: "We now come to the question of the accounts for the past year. I will, therefore, deal as usual with the capital accounts first. The actual capital raised has been increased by £62,500 on account of new shares, and £38,360 on account of 4½ per cent. debenture stock, making the total at present issued of that stock £220,000 out of the £250,000 which was authorised in 1895. The increase of share capital which you will remember was sanctioned at the special general meeting on June 23rd, 1896, to the extent of £500,000, was acted upon by the directors, who, in the month of July, offered for subscription 12,500 shares of £10 each at a premium of £2 per share, and it is a strong testimony to the confidence felt in our undertaking that the whole of this issue was at once applied for to nearly three times the amount required, which, I regret to say, had the effect of causing some disappointment to many of the shareholders whose applications had of necessity to be considered upon the basis of a *pro rata* allotment. I might also add, perhaps, that the terms of the issue were attractive, not only to the general body of shareholders, but also to the Stock Exchange and the investing public, which is a fact not to be overlooked in view of the further issues which must in time be made. The result of the issue has fully justified the expectations of the board, as is shown by the fact that both the old and new shares are standing to-day at what is, after the dividend we are recommending you to confirm, a highly satisfactory premium. No debenture stock has been issued since the authority for new shares was taken, and the balance is held to be issued in case of any future emergency. This increase of capital has provided the necessary funds for the capital expenditure of the year, to which I will now briefly refer. The total net expenditure, after allowing for amounts written down to depreciation, has amounted to £81,551 10s. 11d., and of this the principal items have been due to the extension of business. I allude to the items of mains, transformers and meters, which together represent a total of £53,206 8s. 9d. Looking at the extent of the areas served by this company and the statutory requirements which are involved, it will be at once recognised that our expenditure on mains must continually increase, and the amount shown this year, £27,786 5s. 7d., against £18,026 in 1895, represents a very considerable advance in earning capacity for the future, although an immediate return from this outlay cannot be expected. Transformers £18,507, and meters £6,913, also have to keep pace with the increase of customers, but produce a more prompt return upon the outlay. With regard to the item of transformers, I may point out that as the system of transformer sub-stations which we are now commencing is developed, the expenditure under this head will somewhat diminish. The item of buildings, £7,603, consists to the extent of more than half of purchases of additional property for the extension of works and for the sub-stations already mentioned, the remainder being expenditure on the practical completion of the extensions at Sardinia Street, undertaken in 1895, and to minor additions at the other works. Plant and machinery, £21,565 1s. 8d., practically tells its own tale, and represents £12,475 on account of the new plant for the Sardinia Street extension, £4,500 for Manchester Square, £2,600 for additional boilers, &c., at Amberley Road, and £1,950 for Rathbone Place, the efficiency of each of these stations being thus materially strengthened. The credit item of £6,768 to accumulators means that the whole of the charge hitherto appearing in the accounts under this heading has been written off to the depreciation account. This item, with a sum of £1,025 written off on account of transformers, makes up the £7,793 which appears to the debit of the depreciation account, No. 6. One item yet remains, and that is "compensation, &c.," £4,168, which consists to the extent of £2,570 of what I believe are the final expenses in connection with the Manchester Square vibration litigation, and to the extent of £1,598 of the cost of rebuilding the property known as

the "John of Gaunt," in Sardinia Street, which now becomes a valuable portion of the company's premises. Upon the revenue, with its story of earnings and expenditure, the welfare of the company depends. The revenue income has grown during the year by the sum of £10,011, not so large an increase as in former years, but satisfactory, inasmuch as the increase in the demand has been encouraged by advantageous terms which have been given to our best customers, thus securing a more continuous demand, and thereby enabling the highly gratifying decrease in the cost of production, to which attention is specially drawn in the report. We have every reason to feel confident that, with the improvements which are continually being developed in our system of distribution, we may have the pleasure of recording a similar progress in future years. The figures given on the expenditure side of the account are of great interest. You were told last year that the expenditure of 1895 had been abnormally increased under all headings by the conditions brought about by the fire at Sardinia Street in that year, and in confirmation of that statement, it will be seen that with a largely increased output, the cost of production has, owing to the economies which have been found practicable, only gone up by the small sum of £82, and this with the price of coal per ton slightly in advance of 1895. A comparison of the items for the two years shows so close a correspondence all through, that I need not trouble you by going through them in detail, but will turn at once to the general result. The gross profit, before allowing for depreciation, is £46,191, against £39,154 in 1895. Of this we have again written off £12,000 to a depreciation account. This amount has been arrived at after a careful consideration of the whole position of the company's assets and prospects, and the board consider that they are making all the provision which can justly be looked for. Turning to the net revenue account, No. 5, it will be seen that after taking advantage of various sources of additional profit, and allowing for the increase of interest on debenture stock and new shares, and also for the closing of the old preliminary expenses account, there remains a balance of £16,028, of which the directors propose to appropriate £14,970 to making the dividend for the year up to 5 per cent. on the ordinary share capital, leaving £1,058 to be carried forward to the next account. Having regard to the conditions of the year's working, and to the fact that interest has had to be provided on a considerable amount of capital expenditure which cannot be immediately productive, I think you will consider with us that the attainment and establishment of what we believe to be a sound 5 per cent. basis is a very satisfactory result. In conclusion, I think you will expect me to say a few words in reference to our future. If you will examine the chart upon the wall, which is a very eloquent testimony to our progress, you will observe that the line which traces the growth of our lamp connections shows no tendency to decline, nor can we see the smallest indication of any falling off in the number of fresh applications. This I am sure you will agree is most gratifying; but at the same time makes it necessary for us carefully to consider our future requirements and responsibilities. It must be obvious to you that our present works have but a limited capacity. Up to the present, and perhaps for a short time longer, we can meet our increased demands by gradually adding to our existing plants; but the time has almost arrived—in fact, at some of our works, has arrived—when such additions will be no longer possible. To provide not only for the next few months, but for the next few years, is a matter which is now receiving our most careful attention. Whatever form this provision may take, you may rest assured that we shall avail ourselves of the best advice obtainable, and that the varied experience which we have gained in the past will be of the utmost service to us. We shall, moreover, be able to take full advantage of the remarkable progress which has been made both in the efficiency of machinery and in methods of electrical distribution during the eight years which have elapsed since we started our business. I have thought it right thus to indicate what is at present occupying a great deal of our attention, as you will at once realise that further capital outlays can be advantageously made before long. I scarcely anticipate that more capital will be required during the present year, but early in 1898 I have no doubt that we shall have ample justification for taking this step. Before I sit down, I should like to mention that one of our generating works is situated in South Street, Manchester Square, within 200 yards of this spot, and to suggest that any of the shareholders who have a few minutes at their disposal might possibly find great interest in looking in there, and seeing for themselves what an electric lighting station really is. I now move the following resolution:—"That the report and accounts for the year ended December 31st, 1896, presented to this meeting be, and are hereby, approved and adopted, and that in addition to the interim dividend of 4s. per share paid on October 15th, 1896, a further dividend of 6s. per share on the whole of the original ordinary shares of the company be, and the same is hereby, declared, such dividend of 6s. per share to be payable on March 30th, 1897, to all holders on the company's register on March 19th, 1897."

Admiral Lord John Hay, F.C.B., seconded the motion.

The Chairman, in reply to several questions, said he agreed that while they had founders' shares they should only issue new shares at par, but there were so many points in connection with the company, that he could not say definitely that no future shares would be issued at a premium. The question as to whether they should issue shares or debenture stock when raising additional capital had not yet arisen, but when it did the directors would take the best financial advice, and would no doubt come to an arrangement which would be satisfactory to the shareholders. With regard to the Free Wiring Company, that involved a great many difficult questions. Among other things, it gave a monopoly to the company, and as there were an enormous number of persons engaged in the same business, they did not at present see their way to joining that company, but they were in communication with them, and doubtless something would come of it. The matter of the redemption of the founders' shares was occupying the attention of the board, and every effort would be made to bring about a satisfactory settlement.

The report was then adopted.

Mr. Cripps proposed the re-election of the retiring directors—Sir E. M. Shaw, Mr. J. Pender, M.P., and Mr. J. B. Verity.

Mr. F. Bailey seconded the motion, which was carried.

The auditors having been re-elected, the proceedings terminated with a vote of thanks to the chairman and directors and to the staff.

Direct Spanish Telegraph Company, Limited.

The meeting of this company, held on Tuesday at the offices of the company, was presided over by the new chairman, the Marquis of Tweeddale.

Mr. Gerhardi (the secretary) read the notice convening the meeting, and

The Chairman, before moving that the report and accounts be adopted, referred to the death of the late chairman (Sir John Pender). He congratulated the shareholders on the increase of £4,564 in the receipts last year as compared with those of 1895. It was true that the increase was owing to exceptional circumstances—the insurrection in Cuba—but there had been a slight increase in the ordinary traffic during the year. He believed they would not hear very much more about the rebellion in Cuba. He had no doubt that its termination would lead—for the time, at least—to a decrease in their receipts, but, on the other hand, there was every reason to hope that the close of the insurrection would be followed by greater activity in commercial matters. The increase in their receipts had enabled them to recommend the same dividends as those paid last year—10 per cent. on the preference shares and 4 per cent. on the ordinary shares; to add the usual £5,000 to the reserve fund, and to repay to that fund the amount which was taken from it some time ago, partly to maintain the dividend of 4 per cent and partly to defray the cost of repairs. The reserve fund now amounted to very little short of £40,000, which was not nearly sufficient to renew their main cable. One of their cables, the Marseilles-Barcelona line, had been laid 23 years, while the Bilbao-Falmouth cable was 13 years old. For some time to come, therefore, they would have to add a considerable amount to the reserve fund. The increase of £660 in the working expenses was accounted for by the large increase in the number of telegrams which they had had to deal with in 1896, as compared with 1895. The extraordinary expenses—not taking into consideration the £5,410 returned to the reserve fund—were £1,227 less than in 1895; but there had been no expenditure on repairs of cable during the year. There had been an expenditure of £311 for the deviation of and repairs to the underground lines at Bilbao. The deviation of these lines was rendered compulsory by the Municipality of Algorta, near Bilbao, and the "repairs," which were not rendered necessary by any interruption, were more in the form of consolidating and strengthening places in a comparatively weak electrical condition in these lines. The action commenced by the company against the Harbour authorities of Bilbao for the cost of removing the cable, which was rendered necessary by the erection of a breakwater which would have been over the cable, would be tried at the Tribunal de Contencioso at Madrid on the 10th prox. The decision of this tribunal would be final, so that they would know then whether they would recover any portion of the expenditure incurred in removing the cable. The whole expenditure had been written off already, and, therefore, if the decision were against the company, they would lose nothing, while if it were in their favour it would be so much to the good. Among the exceptional items of expenditure was the outlay which had been incurred in connection with the Conference at Buda Pesth—an item which would not recur for the next five years. The principal business at the Conference, so far as this company was concerned, was the arrangement for bringing about a reduction of the rates to Spain. On and after July 1st next the rates to any part of Spain would be 3½d. instead of 4d., and to Portugal and Gibraltar 3½d. instead of 4½d., as at present. They would certainly suffer some loss on the reductions and the alterations in the mode of counting words in telegrams, as agreed to at Buda Pesth, but they believed that the reduction in the rates would lead to an increase of traffic which would almost recoup them for their loss. The company's cables were in good working order.

Mr. Edmund Etlinger seconded the resolution, which was carried unanimously.

After the retiring directors and auditors had been re-elected, a resolution was passed subscribing £100 from the company's funds to the Pender memorial. Votes of thanks to the chairman and directors closed the meeting.

The British Aluminium Company, Limited.

The directors' report, to be presented at the second ordinary general meeting of the shareholders, to be held at the Westminster Palace Hotel on Thursday, April 8th, 1897, at 12 30 o'clock, says:—"In presenting their second annual report to the shareholders, the directors announce that a profit of £5,744 8s. 10d. has been made, which, with £1,123 4s. 2d. carried forward from last year, amounts to £6,867 13s., out of which the directors recommend the payment of 7 per cent. on the preference shares up to January 1st, 1896. Since last year's report, a factory at Greenock has been built and equipped for the purpose of making electrolytic carbons, the other factories have been completed, and great progress has been made with the additional engineering works for the storage of the water at Foyers. In order to supply the growing demand, the directors have decided to increase the plant of the different factories, and the necessary orders to carry out this work have already been given. The directors have entered into agreements to lease water-power to the Acetylene Illuminating

Company, Limited. According to the articles of association, two of the directors, Mr. Harvey du Cros and Mr. Robert Heath, retire by rotation, and being eligible, offer themselves for re-election. The auditors, Messrs. Crewdson, Youatt & Howard, also retire, but offer themselves for re-election."

The Sheffield Electric Light and Power Company, Limited.

The report of directors states that the accounts, made up to December 31st last, which are presented herewith, show the balance of profit as follows:—

	£	s.	d.
Balance from last account	87	18	11½
Net profit for the year	7,635	4	8
	£7,723	3	7½
From which must be deducted:—			
Interest on debentures £1,125 0 0			
Balance of formation expenses written off 445 9 0			
Transfer to depreciation fund ... 1,000 0 0			
	2,570	9	0
Leaving a balance of	£5,152	14	7½
The directors recommend the payment of a dividend after the rate of 7½ per cent. per annum, free of income-tax, which will absorb	4,053	1	8
Leaving a balance of	£1,099	12	11½

out of which the directors have set aside a reserve fund of £1,000, leaving a balance of £99 12s. 11½d. to be carried forward. The issue of shares referred to in the last annual report was wholly taken up, and realised a premium of £1,739 10s., which it is proposed to transfer to the credit of the depreciation fund, making a total of £4,739 10s. now standing to the credit of that fund. The whole of machinery and plant of the company is in excellent order and condition. Of the 14,000 shares into which the company's authorised capital is divided, there only now remain unissued 1,896 shares, and these the directors propose at once to offer to the shareholders in proportion to their present holdings; but in view of the present market price of the company's shares, it is proposed to offer them at £2 per share premium. The growth in the demand for electric light is indicated by the following statement of the company's revenue from the sale of current during the four complete years of its operation:—

1893	£3,555	11	0
1894	4,849	9	4
1895	6,935	4	1
1896	11,257	15	4

Whilst the company's business is thus steadily increasing, great economies have been effected in the costs of production, and in the working costs. In consequence of the satisfactory results of last year's working the directors, on January 1st last, reduced the price of current from 6d. to 5d. per Board of Trade unit, and they hope that the increased demand following upon this reduction will justify their policy of sharing with consumers the results of the prosperity and growth of the company's business. During the past year a sum of £18,394 12s. 1d. has been expended upon machinery, mains, and other appliances. In order that the company's business may be more satisfactorily dealt with, a building site at the corner of Commercial Street has been purchased, and upon which offices, show rooms, and other necessary accommodation are now being constructed. The proposed issue of shares will exhaust the company's nominal capital, and as the rapidly increasing demand for the supply of electricity will require further capital expenditure, it is proposed to ask the shareholders to pass the necessary resolution for increasing the capital from £98,000 to £280,000. The directors retiring by rotation under the company's articles are Mr. George Senior and Mr. Wm. Tasker, who, being eligible, offer themselves for re-election. The company's auditors, Messrs. T. G. Shuttleworth & Son, also retire at this meeting, and are also eligible for re-election.

Eastbourne Electric Light Company, Limited.

The annual meeting of this company took place on Monday last week, at the Clifton Hotel, Eastbourne.

Mr. G. Boulton (the chairman) presided, and in moving the adoption of the report, which recommended a dividend of 7½ per cent., congratulated the shareholders on the prospects and progress of the company. The company, he reminded them, was started in 1882, and in spite of many obstacles and the obloquy of jealous rivals, they had continued for a period of 15 years. By the good service of their engineers and secretary they had overcome all difficulties, and now, as in the last two years, they offered the shareholders what he called a very fair percentage for their money. The dividend for the first 10 years of the working was very small. The dividend paid in 1892 was 3 per cent.; in 1893, 5 per cent.; and in 1894, 7½ per cent.; and that was the dividend the directors offered this year. He wished it had been 10, but they had been at considerable expense during the year. Those expenses had been charged to revenue, and not, as was usually done in companies of that kind and companies of another character, to capital. It was easy to charge expenses to capital—increased capital, increased revenue, increased dividends—but it was not fair. That was not the right way to do business. The right way was to pay out of their earnings the necessary expenses that accrued during the year, and to pay a dividend out of the balance. That the directors took credit for having done. The profits on shares had not been brought into account, but had been carried to the reserve fund, by which means that reserve fund had been raised to £2,500. They had now over 12 miles of double cable and between three and four miles of single cable laid. When they considered that they had the greatest difficulty in obtaining permission to lay an inch of cable to begin with, he thought that was satisfactory.

Mr. Langham, in seconding, said during the year 764 new shares were disposed of at a profit of £1,938. That had been paid to what they called the reserve fund. There were two reserve funds. One was called the depreciation fund, which was intended as a means of making good defects in plant, and there was a separate reserve fund, which was intended to meet any unforeseen expenditure, or for equalising the dividends, &c. Some of their critics alleged that they had not a sufficient depreciation fund. It should be borne in mind, however, that the reserve fund could be applied to depreciation purposes. At that moment they had a total reserve fund, including the depreciation fund, of over £5,000. That, he thought they would say, was a very good feature, putting the company on a very solid and safe basis for, he hoped, many years to come. He wished to point ont the very steady way in which the electric light was extending throughout Eastbourne. At the end of the year the arc lights and incandescent lamps of 8 candle-power numbered 16,690, as against 14,754 at the end of 1895, being an increase on the year of 1,906 lamps. As showing they were still going on in the same happy way, he might mention that in January last the number of lamps had mounted up to 16,834.

The motion was carried. Mr. Boulton was re-elected a director.

Rockhampton Gas and Coke Company, Limited.

The directors' report states that, viewing the business as a whole, the position is rather better than for the preceding half-year. The number of gas consumers continues to increase, but without a corresponding expanse in the quantity of gas consumed. The greatest possible economy is still being observed in the matter of light by the company's customers. The consumption of electricity has fallen, but the directors hope to provide for this shrinkage by pushing the use of large arc lamps for public purposes, and also by the introduction of electrical fans and small motors. To maintain the plant and buildings of both sections of the business to the usual standard of efficiency, the large sum of £715 18s. 4d. has been spent, and the fund which is devoted exclusively to this purpose has been reduced by that amount. The gas operations show a profit of £1,790 2s. 1d. for the half-year, which with the unappropriated balance brought forward of £188 8s., leaves a credit balance of £1,978 10s. 1d. The electrical operations show a return of £219 5s. 6d., which has gone towards the payment of debenture interest, amounting to £300, the whole of which has been charged to the electric light operations, leaving a difference of £80 14s. 6d., represented in the debit balance of the profit and loss account of this section of the business. The net profit for the whole of the company's business is £1,897 15s. 7d., and from this the directors recommend the payment of a dividend at the rate of 6 per cent. per annum upon the ordinary shares, and 9 per cent. per annum upon the preference shares, amounting to £1,454 1s. 3d., free of dividend duty, and placing the balance, £443 14s. 4d., to the credit of reserve fund for the maintenance and improvement of plant.

The Direct United States Cable Company, Limited.—The board have resolved upon the payment of an interim dividend of 2s. 6d. per share, free of income-tax, being at the rate of 2½ per cent. per annum for the quarter ending March 31st, 1897, such dividend to be payable on and after the 24th proximo.

Eastern Extension Telegraph Company, Limited.—The directors have, subject to confirmation by the shareholders, declared a dividend for the quarter ended December 31st last of 2s. 6d. per share, together with a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year 1896. The dividend and bonus will be paid on 29th inst.

Globe Telegraph and Trust Company, Limited.—The directors announce an interim dividend, payable on and after April 30th, of 3s. per share on the preference shares, less income-tax, and of 2s. 6d. per share on the ordinary shares (income-tax already deducted).

Stock Exchange Notice.—Application has been made to the Stock Exchange Committee to appoint a special settling day in and to grant a quotation to—City and South London Railway Company—20,000 5 per cent. perpetual preference shares.

Edison Gower-Bell Telephone Company of Europe, Limited.—A meeting of this company was held at the offices, 186, Shaftesbury Avenue, on Wednesday afternoon.

South London Electric Supply Corporation.—Letters of allotment and regret have been posted.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending March 28th, 1897, were £974; week ending March 20th, 1896, £918; increase, £56; total receipts for half-year, 1897, £13,972; corresponding period, 1896, £12,656; increase, £1,136.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 26th, 1897, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,016.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1894.	1895.	1896.	Closing Quotation, March 17th.	Closing Quotation, March 31st.	Business done during week ended March 31st, 1897. Highest.	Lowest.
175,400£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	...	100 —104	100 —104	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	4 — 5	4½— 5½	...	...
1,912,880£	Anglo-American Teleg., Ltd.	Stock	£2 2s.	£2 9s.	£2 13s.	50 — 53	50 — 56	51½	51
2,993,560£	Do. do. 6 % Pref.	Stock	£4 4s.	£4 18s.	£5 6s.	95 — 96	94½— 95½	96	95
2,993,560£	Do. do. Defd.	Stock	...	...	...	8 — 8½	8 — 8½	8 3/16	...
130,000	Brazilian Submarine Teleg., Ltd.	10	7 %	7 %	...	15½— 15¾	15 — 15½	15 7/16	15 1/16
75,000£	Do. do. 5 %, Debs., 2nd series, 1905	100	5 %	5 %	...	113 —117	113 —117	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	2½%	4 %	...	3½— 3¾	3½— 3¾	...	...
18,880,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	165 —170	162 —167	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	1½%	1½%	...	1/16— 3/16	1/16— 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	10½— 11½	10 — 11	10¾	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	19 — 20	19 — 20	19½	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	3½— 4½	3½— 4½	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	4½%	4½%	4½%	105 —108%	105 —108 %	...	...
60,710	Direct United States Cable, Ltd.	20	2 %	2½%	2½%	9 — 9½	8¾ — 9¼	9¼	9½
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½%	6½%	...	17 — 17½	17 — 17½	17⅝	17½
70,000	Do. 6 % Cum. Pref.	10	6 %	6	...	18 — 19	18 — 19	18⅝	18½
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	...	103 —105	103 —106	...	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	...	127 —130	127 —130	129	127½
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7%	17¾— 18¼	17¾— 18¼	18 3/16	17 15/16
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5%	100 —104	100 —104	...	...
194,300£	Do do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5%	101 —104	101 —104	101	...
920,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4%	127 —130	127 —130	...	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5%	100 —104	100 —104	...	...
107,600£	Do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5%	101 —104	101 —104	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4%	107 —110	107 —110	...	...
200,600£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4%	109 —112 %	109 —112 %	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4½%	4½%	...	11 — 11½	11 — 11½	11⅜	11½
180,042	Do. do. 6 % Pref.	10	6 %	6 %	...	17 — 17½	17 — 17½	17⅜	17 5/16
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜%	10 %	...	24 — 25	24 — 25	...	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	...	102 —105	102 —105	102½	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	...	54 — 57	55 — 58	57½	56¾
100,000£	London Platino-Brasilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6%	107 —110	107 —110	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000... ...	5	4 %	4 %	...	2 — 2½	2 — 2½	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 %	5½%	5½%	7 — 7¼	6⅝— 7⅜	7⅜	6⅝
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	16 — 18	16 — 18	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	16 — 18	16 — 18	16½	16
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6 — 6½	6 — 6½	6¼	...
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	103 —106	102 —105	104	103
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	4¼%	5 %	...	5/8— 3/4	5/8— 3/4	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4%	107 —110	107 —110	...	...
11,639	Reuter's Ltd.	8	nil	5 %	...	7 — 8	7 — 8	7¾	...
3,381	Submarine Cables Trust	Cert.	...	...	...	138 —143	138 —143	...	...
58,860	United River Plate Teleph., Ltd.	5	3 %	4 %	...	3½— 3¾	3 — 3½	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	...	100 —105	100 —105	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	nil	4 %	...	5 — 6	5 — 6	...	...
223,390£	Do. do. do. 5 % Debs.	100	5 %	5 %	...	101 - 104	101 —104	...	...
39,066	West Coast of America Teleg., Ltd.	10	nil	nil	...	¾ — 1¼	¾ - 1¼	1⅛	...
159,866£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	...	100 - 106	101 -107	105½	...
64,248	Western and Brazilian Teleg., Ltd.	15	3 %	3 %	...	7⅞— 8¼	7⅞— 8¼	7⅞	...
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	...	6¼ — 6⅝	6¼ — 6⅝	6⅝	6⅝
33,129	Do. do. do. Def. Ord.	7½	1 %	1 %	...	1¾ — 2¼	1¾ — 2¼	...	...
155,280£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	...	112 —116	112 —116	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	...	109 —113	109 —113	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅞%	⅞%	...	1 — 1¼	⅞ — 1¼	...	...
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	...	11¼— 11⅝	11 — 11½	11⅜	11¼
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	...	9¼— 10¼	9¼— 10¼	...	...
89,800£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	...	107 —110	107 —110	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7%	107 —112	107 —112	...	...
164,360£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6%	100 —105	100 —105	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4½%	5 %	6 %	10½— 11½	10½— 11½	11	...
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	5 %	5 %	5 %	9 — 9½	9 — 9½	9⅛	9
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	4½%	4½%	112 —115	112 —115	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	5 %	5 %	7 %	19½— 20½	19½ - 20½	19⅛	19½
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	16½— 17½	16½— 17½	17 1/16	17
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	132 —136	132 —136	133½	...
22,475	County of Lond. & Brush Prov. E. Ltg. Ltd., Ord. 1—22,475	10	...	nil	nil	11½ - 12	11½— 12	11⅛	11¾
20,000	Do. do. do. 6% Pref., 40,001—50,000 ...	10	...	6 %	6 %	14½— 15	14½— 15	...	...
10,000	Do. do. do. iss. at 2 pm., all paid	10	...	...	...	14½-- 14⅝	14½— 14⅝	...	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	3 %	4 %	...	15½— 16½	15½— 16½	16½	16
12,500	Do. Ord., 50,001—62,500, iss. at £2 prem. ...	10	...	...	...	11½— 12½	11½— 12½	12¼	12
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	...	120 —124	120 —124	122	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	1 %	2 %	4 %	12 — 13	12 — 13	12⅜	...
19,980	*St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	6½%	7½%	10½%	14 — 15	14 — 15	14 1/16	14½
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	9 — 10	9½— 10½	10	9¾
50,000	Do. do. 4 % Deb. stock Red. ...	Stock	...	...	...	104 —107	104 —107	...	...
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	5 %	7 %	9 %	13 — 14	13 — 14	13⅞	13½

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

§ Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1894.	1895.	1896	Closing Quotation. March 24th.	Closing Quotation March 31st.	Business done during week ended March 31st, 1897. Highest.	Lowest
90,000	Brush Elecl. Engng. Co., Ord., 1 to 90,000...	£	2½%	...	...	¾— 1	¾— 1	...	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	£	3 %	...	...	1¼— 1½	1¼— 1½	1⅝	1½
125,000	Do. do. 4½ % Perp. Deb. Stock.... ...	Stock	4½%	...	...	104 —108	104 —108	...	...
76,770	Do. do. 4½% 2nd Deb. Stock Red. ...	Stock	...	...	...	95 — 99	95 — 99	...	...
9,104	Central London Railway, Ord. Shares	£	...	...	...	9½— 10	9½— 10	10	9⅝
207,649	Do. do. do. £6 paid	£	...	...	...	5½— 6	5½— 6	...	...
630,000	City and South London Railway	Stock	1⅛%	1⅛%	1 1/16%	59 — 61	59 — 61	60¼	60
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	£	*nil*	*nil*	...	1⅜— 2½	1⅜— 2½	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	£	5 %	5 %	...	1⅜— 2½	1⅜— 2½	...	...
17,139	Do. do. do. "A" Shares 01—017,139	£	5 %	5 %	...	3 — 4	3 — 4	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	4½%	4½%	...	105 —110	105 —110	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	£	*nil*	5 %	...	1½— 1⅝	1½— 1⅝	1½	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	£	7 %	7 %	...	2⅜— 3¼	2⅜— 3¼	2⅞	2⅝
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	£	*nil*	...	...	⅞— 1⅛	⅞— 1⅛	1	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	£	*nil*	...	...	⅜— ⅝	⅜— ⅝	...	...
9,600	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	£	*nil*	10½%	...	11 — 12	12 — 14	...	..
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	£	6 %	8 %	10 %	19½— 20½	19½— 20½	20	19⅝
3,000	Do. do. do. 7% Pref.	£	7 %	7 %	7 %	18½— 19½	18½— 19½	...	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	4½%	4½%	107 —112	107 —112	...	...
56,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	£	10 %	10 %	10 %	20½— 21½	20½— 21½	21⅜	20⅞
300,000	Do. do. do. 4 % 1st Mort. Debs.	£	...	...	...	106 —109	104 —107	105½	105
37,500	†Liverpool Overhead Railway, Ord.	£	1½%	2⅜%	2⅜%	12⅜— 12⅞	12⅞ — 13	...	...
10,000	† Do. do. Pref., £10 paid	£	5 %	5 %	5 %	16⅛ — 16⅝	16⅛ — 16⅝	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	£	20 %	15 %	15 %	36 — 39	35 — 38	37½	35½
150,000	Do. do. do. 5 % Bonds, red. 1899	£	5 %	5 %	5 %	103 —106	103 —106	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000, £8 paid ...	£	..	...		10⅜ — 11¼	10⅜ — 11¼	11	...

Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—5%; 1890—8%

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (£4 paid), 7⅞, £5 (fully paid) 9⅛.

Electric Construction Corporation, 6 % Debentures, 103—105.

House-to-House Company (£5 paid), 7—7½.

Do. do. 7 % Preference, of £5, 9—9½.

Do. do. 4½% Debentures of £100, 108—111.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares (£5 (fully paid) 11½—12; 1st Preference Cumulative 6 %, £5 (fully paid), 8—8½. Dividend, 1896, on Ordinary Shares 7 %.

London Electric Supply Corporation, £5 Ordinary, 1½—1⅝.

Yorkshire House-to-House Electricity Company. £5 Ordinary Shares fully paid, 8½—9. Dividend for 1896—6 %.

* From Birmingham Share List.

Bank rate of discount, 3 per cent. (February 4th 1897).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

On Some Repairs to the South American Company's Cable off Cape Verde in 1893 and 1895. By H. Bennet, Assoc. M.Inst., C.E., Associate. (Read March 11th, 1897.)

(*Concluded from page* 437.)

It is said that many rivers in Australia run underground, and in a paper read in July last year before the Queensland Royal Society by Mr. R. L. Jack, the Government geologist, dealing with the question of submarine leakage of artesian water in Australia, it was shown that an abundant supply of artesian water could be tapped by bores sunk in the dry interior. The water is held in porous strata underlying impermeable strata. The out-crops of the porous strata have been to some extent mapped, and are found at altitudes sufficient to give a "head" capable of forcing the water to the surface in the lowlands of the West. Outcrops of porous rock have been found on the eastern side of the interior of the island continent, at a distance of hundreds of miles, and these absorb the flood waters passing over them along the creek and river beds, and carry them down beneath the more impermeable rocks forming the surface of vast areas in the interior.

The Upper Flinders River when crossing in deep gorges the beds of porous rock rapidly dwindles away, enormous quantities of water being absorbed by these bibulous rocks.

The question arises, Where does the draining out take place? The outflow on the land is not sufficient to account for the loss. The rocks, it is concluded, must outcrop somewhere below sea level, and the constant pressure of water from the head sources on land results in a steady outflow of fresh-water at this lower level.

Far out in the Gulf of Carpentaria, beyond the influence of flood waters from rivers that run into the gulf, fresh-water, it is said, can be drawn up in a bucket. Rocks at a depth of over 1,900 feet close to the edge of the gulf contain artesian water. Off the Victorian coast, it has been said, fresh-water may be obtained from a so-called spring out at sea. In both these cases it seems very probable that a portion of the great quantity of water absorbed by the porous strata may eventually find its way out beneath sea level.

In order to obtain some evidence as to whether shore deposits, or may be even mineral substances, were carried out into deep water by the agency of a submarine river outfall, the writer has, through the friendly offices of Mr. M. H. Gray and Mr. Rudler, both of the Royal School of Mines and of the Royal Geological Society, been favoured with the assistance of Mr. Fred. Chapman, A.L.S., F.R.M.S. Mr Chapman's report upon a most careful microscopical analysis of several specimens of the material composing the sea bottom at and near the locality of the breaks, and in the neighbourhood of Senegal, the writer feels to be a most valuable contribution. For the much-esteemed help of Dr. W. F. Hume, A.R.S.M., F.G.S., as well, in the elaboration of Mr. Chapman's notes, the thanks of the writer are cordially tendered.

A brief reference to Mr. Chapman's report will make perfectly clear to the members present the highly interesting nature and composition of the muds of the sea bottom in the vicinity of Cape Verde.

As to which of these deposits, animal or mineral, have been carried out by strong submarine currents it would be perhaps difficult to determine.

Regarding animal remains, it will have been remarked that sponge-spicules are present in nearly all of the specimens; in some these are both broken and perfect. Now, in the perfect state, the presence of these is indicative of shallow water—100 fathoms or so. In the broken state, it would appear as though they had been subjected to current action, or other rough treatment: this latter may have been the voracity of fishes that had probably swallowed them in shallow depths, and had ejected the imperfectly digested remains in water of greater depth, where they have settled to the bottom and now part of it. The fact of their being found at these depths in a perfect state would seem to show that submarine currents *had* been the cause of their being carried, literally, out of their proper depth.

As regards the mineral deposit, it is interesting and significant to note that in Mr. Chapman's report he says: "The minerals observed are in nearly all instances such as result from the disintegration of *drifted fragments* of the volcanic rocks of the neighbourhood."

This brings to mind the probability of volcanic disturbance having been the cause of the rupture to the cable. The Atlantic Ocean north and south, from Iceland to the Cape of Good Hope, is included in the region of the Western Hemisphere subject to earthquake disturbances; the Azores, the Canary Islands, and the Cape Verde Islands being centres where shocks may be experienced of a severity to cause great damage. In "The Realm of Nature," by Dr. H. R. Mill, it is stated that "many geologists believe that sea water filtering through the bed of the ocean, or buried to a great depth in the lower layers of terriginous deposits, causes explosions in the intensely heated regions below, and that all earthquakes originate from this cause."

It is possible that sea water filtering through the sea bottom into a moderately heated portion of the earth may cause explosions of a minor kind that would cause local disturbance, and an alteration to the features of the surface floor.

This might probably cause great upheavals of mud, and displacements of the sea bed, to the extent of many thousands of tons at a

time—more than sufficient to rupture a telegraph cable were it 50 times the strength.

Before diverting the St. Louis-Fernando cable to the westward off Cape Verde on the occasion of the first repair in 1893, it was well considered that two ways presented themselves of so doing—either up the bank to the eastward, or over a comparatively flat part of the ocean floor to the westward, into deeper water. By carrying the cable directly up the bank, the possibility of its becoming involved in greater masses of slowly moving mud (should this be the correct theory) presented itself; whereas, farther out and in greater depth, it might be inferred that these masses of moving mud would be more distributed, and exert less force upon anything lying across their path. The first mentioned plan was abandoned in favour of the latter, but this had failed to place the cable out of reach of the destructive influences; for, as here related, it broke down again on March 10th, 1895, two years and one month from the date of its restoration in February, 1893.

Compared with its first brief space of three months' working, this second term was quite a long lease. It is now, as the writer has shown, on its third trial over a route to the eastward, and clear of both the former tracks.

Various conjectures as to the causes of the sudden rupture of the cable in 1893 were at the time expressed, one being that of sunken wrecks, as in the days of slave trading with the West Indies, many vessels were destroyed by scuttling and burning on many parts of the African coast by British cruisers. A curious condition of the cable near the breaks was the rubbed and chafed appearance of the outer covering *upon one side only*. The outer taping being rubbed away and the sheathing brightened, gave the cable an appearance of having surged along, or been drawn under, some hard body under great strain. This may have been caused by smooth rock, or boulders on the bottom.

There is not much more that the writer can say, except to draw attention to a few striking facts in connection with these very sudden cases of interruption.

Firstly.—It will have been noticed that very severe weather had obtained prior to, and at the time of the first break in 1893.

Secondly.—It will also have been noted that the second interruption occurred during the great storm of March 10th, 1895; this storm having been experienced in the South, as the weather reports from the Canary Islands at the time testified.

Thirdly.—The remarkable climatic conditions, and the disturbed state of the sea surface in the neighbourhood of the break in 1895, together with the unusual phenomenon observed near to the coast in the vicinity of the gully formation during the repair to, and diversion of, the cable on that occasion.

Fourthly.—That a length of cable was recovered under heavy strain for a distance of two to three miles upon each side of the break in 1893, and also in 1895; the contour lines clearly indicating hollows between higher levels on the bottom at the positions where the ends came up.

Fifthly.—The distance and direction between the position of break of 1893 and that of the break of 1895 coinciding more or less approximately with the profile line A to B, and through that line towards the mouth of the gully formation to which attention has been directed.

Sixthly.—The remarkable difference in the character of the breaks, the one of 1893 being a clean tension break, the one of 1895 showing evidence of violent action.

And, lastly.—The equally remarkable difference in the character of the sea bottom at the position of the two breaks, as disclosed by the microscope; the locality of the 1893 break showing an *abundance* of mineral deposit, and that of the 1895 break a *scarcity*.

No particular cause for these breaks can be insisted upon, because there is no direct evidence in support of any. Nevertheless, there are indications of a character that may encourage discussion, and so help to throw more light upon the origin of this, so far, unaccountable destructive agency on the sea bottom.

To Captain D. Morton and his officers during this, as well as the preceding repair to the Spanish National cable, great credit is due for the careful navigation and excellent seamanship displayed both in connection with the work and in times of difficulty.

In concluding, the writer would here wish to record his deep sense of obligation to the India-Rubber, Gutta-Percha, and Telegraph Works Company for the kind facilities accorded him towards the preparation of this paper, also to those members of the Silvertown staff who have so cordially assisted in its production.

Physical Society.

Ordinary Meeting, March 26th, 1897.

Mr. Shelford Bidwell, President, in the Chair.

At the invitation of Dr. S. P. Thompson, the meeting was held at the Technical College, Leonard Street, Finsbury.

Mr. Rollo Appleyard read a paper on Liquid Coherers and Mobile Conductors, and showed the following experiments:—

1. A glass tube containing mercury and paraffin oil is shaken up until the mercury divides into small spheroids. The resistance of the chain of spheroids under these conditions is several megohms. Coherence can be brought about by a direct current, a spark, or by a Hertz oscillator. The coherence is visible, the spheroids forming into large globules. At the same time the resistance falls to a fraction of an ohm.

2. An unstable emulsion is formed by shaking water and paraffin oil together in a glass tube, called by the author a "rain" tube. The oil may be coloured with alkanet root. By electrification, the water suspended in the oil is suddenly precipitated in a shower through the oil, precisely as rain is precipitated in the air after thunder.

3. A mixture of paraffin oil and water is poured into a photographic dish, just covering the bottom; and a little mercury is poured in. Any two separate globules of mercury in the dish are then connected by wires to a battery of about 200 volts through a reversing key. A momentary tap of the key causes instantaneous deformation of the mercury, especially of the globule connected to the negative pole. If the current is kept on, the negative globule sends forth a long tentacle of mercury across the dish to the positive globule. The tentacle may break into spheroids. Intermediate globules send forth "fingers" towards the positive terminal globule; and by continued application of the current, the "fingers" link intermediate globules, illustrating the nature of liquid coherence. By using the current-reverser as a telegraphic transmitting key, the motions, to right or left, of the "finger" of any stray globube may be interpreted to form the letters of the Morse code. By a succession of taps of the key in one direction or the other, a globule can be made to "caterpillar" along the dish.

Prof. Ramsay said he had once attempted to facilitate churning by the application of 8 or 9 volts to some milk. He thought the cream came a little faster, but it turned sour very quickly.

Prof. Fitzgerald thought that the effects observed in experiment (3) were the result of current, and not of electrostatic charges; and he would like to know the value of the actual current used. There was no doubt that the motions were due to variations in capillarity.

Mr. Shelford Bidwell asked how the mercury was formed into spheroids in the tube in experiment (1).

Mr. Appleyard, in replying to Prof. Fitzgerald, said it was not easy to define the circuit, as the terminal globules were rather capricious, but he would try and measure the current in some particular case. The mercury tube in experiment (1) was shaken in a horizontal plane; the operation took about 10 minutes. Equal volumes of mercury and oil was a good proportion. One quarter of the length of the tube should be left as an air space.

Prof. Dalby then exhibited five pieces of apparatus. (1) A kinematic slide; (2) An inertia apparatus with trifilar suspension; (3) A Wilberforce spring; (4) An Ewing's reading telescope; (5) A kinematic Hook gauge. Models (1), (2), (4) and (5) illustrated the various degrees of freedom of bodies restrained at different numbers of points. It was shown with (3) that in extending a spiral spring, there results a certain amount of twisting. If a mass is hung at the lower end of the spiral in such a way that, when suddenly released after extension of the spring, the time of oscillation of the mass in the horizontal plane (rotation) is the same as the time of vertical oscillation; then the tendency to twist results in a change of energy which alternates between the rotary and linear forms.

Mr. Boys drew attention to the conditions of restraint, and suggested a criterion for determining whether a piece of mechanism was designed for minimum strain on the structure; a thin wedge slipped under any one point of contact should not disturb the other points of restraint.

Prof. Fitzgerald pointed out the effect of symmetry upon the motion of the spring of (5). The spiral happened to be an unsymmetrical form, the change of phase from vertical to rotary oscillation was therefore rapid. In the case of the vibration of a symmetrical stretched cord, the change of phase would be very slow.

Dr. Thompson exhibited two kinematic models, depending upon the principle that any simple harmonic motion may be considered as the resultant of two oppositely directed motions. The first illustrates the synthesis of two opposite circular motions of equal period and amplitude to form a straight line motion: the second shows the combination of two simple harmonic motions of equal period and amplitude in any difference of phase, to form a circular motion. In each case the motion is communicated to a stylus by a link gear, operated by two wheels rotating in opposite directions. In the first apparatus the wheels are pivoted about their centres, and the link gear is pinned to one point on the flat surface of each wheel, near the circumference; in the second apparatus, the wheels rotate as eccentrics at 180° to one another, and the motion to the link gear is communicated by thrust rods, held by springs against the peripheries of the corresponding wheels. Dr. Thompson further exhibited a device for projecting, by lantern, the rotating magnet and copper disc of Arago. The curious rotations and lateral movements of iron filings in a revolving magnetic field were similarly projected on a screen. He also showed some experiments with a heat-indicating paint, made from a double iodide of copper and mercury, discovered 20 years ago by a German physicist. At ordinary temperatures the paint is red, but at 97° C. it turns black. If paper is covered with this substance, and then warmed at a stove, the change is effected in a few seconds. Various designs can be wrought upon the back of the paper in dead-black or gold, so that when warmed they appear in red or black on the front, according to their respective absorptive powers. Or local cooling by the hand will yield a silhouette. If the paper is allowed to cool the silhouette vanishes, but it appears again when the paper is reheated. It has thus a kind of thermal "memory." A yellow double oxide of silver and mercury is even more sensitive. It changes from yellow to dark red at 45° C. Lastly, Dr. Thompson exhibited a kinematic model of Hertz-wave transmission. A row of lead bullets is suspended from strings, so that the bullets hang clear of one another by about an inch, in a right line. The strings are meshed, and herein the model differs from the well-known wave models used in acoustics. If the attempt is made to send an acoustic form of wave through the system by giving an impulse to the first bullet in the plane of the other pendulums, it fails immediately, owing to the slackening of parts of the meshes. Thus, only *transverse* vibrations can be transmitted. To illustrate the propagation of a Hertz wave, a heavy pendulum oscillating in a plane at right angles to the line of bullets, at one end, represents the Hertz "oscillator." A metal ring, mounted horizontally

on a trifilar suspension, and properly "tuned," represents at the distant end the Hertz "resonator." Waves formed by the transverse vibrations of successive bullets are then propagated from end to end.

Prof. Fitzgerald said the model was specially interesting as illustrating the difference in velocities of propagation of a given wave, and of the energy corresponding to it. The model did not accurately compare with ether, because in ether the rate at which the energy is propagated is the same as that of the wave. The difference of the two rates, for any medium, depended upon the "dispersion" of the medium. By slight alteration of the pendulum suspensions this dispersion might be made different at different parts of the model, and would then correspond to certain known cases of "'anomotous' dispersion." Or, again, it might be made to illustrate the theory of Helmholtz with regard to the vibrations of the molecules of glass; according to which, the vibration of the molecules alters the vibrations of the waves, so that dispersion occurs, and the energy is not propagated at the same rate as the waves themselves. It was shown by Michaelson that it was possible to have a medium in which the energy is propagated in one direction, and the wave in another. This was attained in a magnetic model by Ewing. The mesh apparatus indicated how a model could be made which should give out "harmonics" and "over-tones" very different from one another, where different wave lengths would be propagated with different velocities, and the over-tones would correspond to the differences. Further, it indicated a mechanism for producing any desired spectrum; such, for instance, as that of hydrogen. A somewhat similar model had been designed by Glazebrook for illustrating the absorption bands of a medium when the rate of vibration was the same as the free period of the vibrations of each of the molecules, which is the theory of Helmholtz; but it was not such a simple model. The experiment of red paper changing to black was interesting as illustrating a red spectrum varying with temperature.

Mr. Shelford Bidwell proposed votes of thanks to all the exhibitors, and the Society adjourned until April 9th.

THE ELECTRIC LIGHTING OF COUNTRY HOUSES.*

By A. H. I. GRAHAM (Student).

Introductory.—In this paper, by country houses is meant any fairly large private house situated at a distance of three miles or more from the nearest town. Of such houses, there are a considerable number at present lighted by oil lamps, and in a few cases by gas. For small houses the former is, perhaps, the most convenient and economical method of lighting, but in large houses the work of filling, cleaning, and trimming the lamps becomes an important consideration. The reason that owners of country houses have not more generally adopted the electric light, is perhaps, the want of some knowledge on the subject. Until recent years, the electric light was looked upon as only obtainable at considerable cost from a supply company's mains, and at the present time there exists among many an idea that an electric lighting plant entails an enormous initial outlay with a considerable cost of maintenance. Further—and this has, perhaps, been still more injurious—there seems to have been an idea that the light was not to be depended upon.

I hope to show in the course of this paper that the initial outlay for plant is not very great, and that the light once installed is not much more expensive than other illuminants, and, in some cases, is even more economical.

Choice of Motive Power.—Having decided to adopt the electric light, the first point to be considered is what motive power should be used. In this we are chiefly guided by the locality of the house, and the cost of fuel delivered on the premises.

The choice of suitable motive power is the most important point, as the rest of the installation can be very little varied. We have to decide between steam, gas, oil, or water. There is also another power, though at present little used, but upon which a few words may be of interest, viz., wind power.

Wind.—There seems at first sight no reason why windmills should not be used to drive a dynamo to charge accumulators. It has, however, been found that great difficulties arise on account of the variation in the velocity of the wind. During the summer months, moreover, there may be calms for perhaps several days. A windmill for the purpose should be capable of working with any strength of wind, should be always ready to start, and should run for a long time without attendance.

† Windmills have been extensively used as motive power in America, and not always with unfavourable results. At Marblehead a steam engine was displaced by a windmill with a wooden wheel 20 feet diameter, on a tower 75 feet high. It drove a dynamo wound on the Lewis system for speeds varying from 750 to 1,500 revolutions per minute, and having an output of 2 kilowatts at 1,200 revolutions. The Lewis device consists in winding the dynamo with a reversed main coil, so that as the speed rises the E.M.F. tends to rise, causing a corresponding increase in the reversed main coil. This in its turn tends to weaken the field, with the result that the E.M.F. remains constant, in spite of the increased speed. Comparing the cost of this plant with that of the steam plant which it replaced, we are given the following figures:—

Steam plant for 75 lights—				
Original cost	...	...	...	£200
Total yearly cost	...	...	...	65
Wind plant for 127 lights—				
Original cost...	...	...	...	£360
Total yearly cost	...	...	...	50

A means of getting over the difficulties of speed regulation is by, so to speak, storing the wind, that is, storing the energy in compressed air, the mill driving air pumps compressing air into reservoirs. The advantage of this method is, that the plant can be worked at any speed. This, however, would entail a considerable outlay for first cost.

Water.—Where there is a stream or lake in the neighbourhood of the house, the power which can be derived from it should be ascertained, as, if this is sufficient with water power for the purpose, there being no consumption of fuel the working cost will be very small. If a stream, the supply should be fairly constant, not being liable to be flooded in winter or dried up in summer; it should not be at any great distance from the house, or the cost of conductors will be large, with a considerable loss in power from the source to the house; also, there will be the inconvenience of looking after the plant.

There are several methods of determining the power to be derived from streams; the following is a simple one:—

Take a board with a ⌐ notch cut in it, and with it form a dam across the stream, the notch being sufficiently large to pass all the water to be measured; a stake should be driven into the bottom of the stream a few feet up from the weir, the top of it being level with the bottom of the notch. When the water is flowing freely over the weir measure the depth of the top of the stake from the surface of the water. The water should have a clear fall of at least 6 inches below the crest of the weir.

The quantity flowing may be then obtained from the formula $5\sqrt{d^5}$, where d is depth of water in inches. This gives the quantity in cubic feet per minute flowing over each foot in width. Then the horse-power obtainable can be got by multiplying this quantity by the available height of fall and by the weight of 1 cubic foot, and dividing the whole by 33,000, *i.e.*, H.P. $= \frac{Q \times H \times 62{\cdot}4}{33{,}000}$

To obtain the effective power, this should be multiplied by the efficiency of the motor, which, for turbines, may be taken as ·70. For large quantities of water an easier plan is to select a part of the stream where the flow is uniform, find the average cross section in feet, and the velocity at this part. This may be done by dropping in a float, and noting the time taken to pass over a known distance. Then multiply the sectional area by velocity in feet per minute, and the product will be the number of cubic feet per minute flowing in the stream. The horse-power can then be obtained as before.

We may assume that about 700 cubic feet of water falling 1 foot in one minute are required for each horse-power. Desirable as water-power may be, we shall do well to thoroughly investigate the case before proceeding, for like everything else, it has its disadvantages. For fear of the water getting frozen in winter, it is sometimes found necessary to have a stand-by plant; further, in this country, many of our streams and rivers have got milling rights which render it impossible to employ the power at hand.

Where water-power is not available, a steam, gas, or petroleum engine must be used.

Gas.—Where gasworks already exist for supplying the house, it will be found most convenient to use gas engines, the cheapest coal being employed instead of the expensive coal necessary for the production of illuminating gas.

The consumption of coal gas in gas engines is about 20 cubic feet per brake horse-power-hour. As each horse-power supplies current for about 15 lamps of 16 C.P., we have a gas consumption of about 1½ cubic feet per hour for each 16-C.P. lamp, whereas the gas consumed direct, about 5 cubic feet per hour, must be allowed for each 16-C.P. burner.

Gas engines can be still more economically run by using producer or power gas; a brief description of the plant for its production may be of interest. The plant consists of a wrought-iron generator, a small vertical boiler, two scrubbers, and the gas holder. To start production, nothing is required but anthracite or coke to fill the generator, and water to evaporate into steam for injection into the fuel, the steam pressure being about 40 lbs. per square inch. The boiler has a closed grate, and tubes in the up-take, in which the steam is superheated before passing to the lower part of the generator. Between the boiler and generator is an injector through which a current of air is forced by the velocity of the steam. The gases generated by the combustion of the anthracite or coke combine with the oxygen derived from the decomposition of the steam and air, and are conveyed through a cooler to a hydraulic box partly filled with water, where they are washed, and a pipe then conveys them to the scrubbers. One of these is filled with coke moistened by water, the other filled with sawdust. From here they pass into the gas-holder.

By this means producer gas can be obtained at a cost of from 2d. to 3d. per 1,000 cubic feet. This gas requires less air for its combustion in the cylinder of a gas engine than ordinary gas. The plant is compact and simple, occupies a small space, and requires little attention; the gas can be made continuously and rapidly, and deposits no impurities in the ports and valves of the engine. The fuel consumption is about 1¾ lbs. coke, or 1½ lbs. anthracite, per H.P. hour. Engines, however, driven with cheap gas, give less power for the same cylinder dimensions than with lighting gas, but the explosions are less violent, and the heat generated is not so great, and conse-

* Paper read before the Students of the Institution Electrical Engineers, March 3rd, 1897.

† Electrical Review, Vol. 35.

quently the wear and tear of the parts is rather less. As, however, very few country houses have private gas plants already installed, unless producer gas be used, we are left to choose between the steam and oil engine. Where the power required is not greater than about 20 H.P., as will be the case in most country houses, it will be found more convenient and economical to use petroleum engines.

It will be readily seen that for isolated plants of this description it possesses several advantages over the steam engine.

In the first place, a steam engine, which entails a boiler occupies a larger space, the water obtainable may not be suitable for use with steam engines, a larger space is also required for storage of fuel, and a considerable time is taken in starting. On the other hand, an oil engine is compact, easily started in a few minutes, there is no smoke, no ashes, no water gauges or safety valves to watch, no fire, the cleaning required is almost nothing compared to boiler and steam engine, and finally, what is of great importance in the case of country houses, no regular attendance is required.

The consumption of oil in these engines varies from $\frac{3}{4}$ to 1 pint per H.P. hour, or about $\frac{1}{2}$d. to $\frac{3}{4}$d. per B.H.P. per hour, which will be found to show a considerable economy over small steam engines. However, where the power required exceeds about 20 H.P., unless two engines be used it will be found more satisfactory to use a steam engine, the extra attention and space needed being probably of less importance.

Accumulators.—Having from the foregoing remarks decided upon the motive power to be used in any particular case, we can now consider the rest of the installation.

Accumulators for country house lighting are absolutely essential, for should anything happen to the plant, without them the house would be left in darkness; again, direct running means working the entire plant and keeping somebody up till perhaps 12 or 1 o'clock at night for the sake of one or two lights. They are necessarily an expensive part of the plant, but if properly attended to their maintenance is not very much; in fact, for the first few years it is practically *nil*. Most makers will now, for a small percentage on the original cost, periodically examine the battery and keep it in working order, supplying and fitting new material in exchange for the old when necessary. The advantages of this in isolated positions can be readily seen. Were it possible to do away with accumulators and at the same time have a satisfactory installation, we should succeed in lessening the first cost considerably and also save some after troubles.

Dynamo.—As regards the generator nothing need be said, for if the man in charge will but keep it lubricated and follow the instructions sent out with each machine, it will run for years without giving any trouble.

Switchboard.—The switchboard should be fitted with the various voltmeters and ammeters necessary, and there should also be a recording meter in order to read the battery charge and discharge, and by this means a check can be kept on the efficiency of the plant, and especially on the state of the cells.

Cost of Installation.—As regards the cost of installing a lighting plant, it is very difficult to give any fixed figures, as by using elaborate fittings, more for beauty than for use, the cost may work out to practically anything.

Buildings.—In most cases it will be found that there are some outhouses which can be easily turned into an engine house. It is advisable where possible that this should be at a distance of from 50 to 100 yards from the house, as this will do away with any inconvenience from smell or vibration. The battery room may be in the same building as the engine, or as is often found more convenient, nearer to the house.

Design.—An important point in the design of a country house installation is the number of lights usually alight at a time, also what the maximum demand may be. These will be found to differ in almost every case, as no two houses can be said to be alike. The plant laid down should be large enough to allow for extensions, as though the house itself may be completely lighted, there are many further uses to which the plant may be put during the daytime, such as for indoor use, boot-cleaning machines or a lift either from the kitchen to the dining-room, or for taking luggage upstairs. This subject will be dealt with more fully later.

If the installation is a very large one, it may be found more convenient to run direct for the first part of the evening when the load is greatest, and only rely on the battery to do the light load.

Man in Charge.—This brings us to the important question of the man in charge of the installation. In most cases during the erection of the plant the gardener, stable boy, or someone equally incapable, is put to learn the various parts of the machines and his duties in connection with them. After a trial run, the entire plant is handed over to him, and is under his sole charge. Certainly we are told that the work is so simple that anyone can do it, and, in fact, we have heard in one case of a plant being in charge of a housemaid, but whether this is advisable is doubtful. Undoubtedly gas and petroleum engines, as far as starting and shutting down is concerned, require no skill; but the man in charge of an installation comprising steam engine, boiler, and storage cells, especially for the latter, should have had some experience of the work. Storage cells do require a certain amount of attention if they are to be kept in proper condition, as if they are once allowed to run down, the plates get buckled and short circuited, which means a considerable further outlay for repairs. Probably in nearly every case a skilled attendant would in this way repay for the extra wages by detecting faults in good time and doing his own repairs.

Cost of Working.—As regards the relative working costs of lighting by electricity and by oil, I have endeavoured to obtain some information from those who have the electric light installed, but in most cases, though they seem to know exactly what the electric light costs, it has been difficult to obtain reliable figures of the previous cost of lighting by oil. In the following case, however, the cost of oil lighting may be taken as a minimum for the size of house in question, which contains about 40 rooms, and though in this instance the electric light has not been yet installed, tenders have been received, from which we may arrive at a very fair idea of what the cost will be. The average cost of lighting by oil lamps over three years works out to about £20 per annum. From the estimate for the electric light, which was for a 6 B.H.P. petroleum engine, we have the following figures:—The battery, when charged, would maintain 100 8-C.P. lamps for six hours. Taking a mean for winter and summer of five lighting hours per day, and an average of 30 lamps alight at a time for these five hours, we see that the battery will only need recharging once every four days. Let us assume it to be every three days, that is, about 122 times in the year, and that the time taken to charge is seven hours, making a total of 854 hours for running the engine. This, at $\frac{1}{2}$d. per H.P. hour, works out to about £10 10s., or at $\frac{3}{4}$d. per H.P. hour, £16. Besides this cost, we have practically only the cost of lubricating oil and sulphuric acid, so that the light would be very little more expensive than previously.

With regard to this installation, it should be remarked that though water-power was abundant, the nearest point from which it could be obtained was about two miles distant, and it was found to be much more economical to use an oil engine, on account of the large cost of conductors which would have been necessary, and the trouble which looking after them would have entailed.

I will now give some figures which I have obtained of annual cost of some working installations.

1. *Gas Engine Plant.*—The plant consists of a 7 H.P. gas engine, dynamo and accumulators. The gas is obtained from a neighbouring town, a distance of three miles, the cost of gas being 3s. 3d. per 1,000 cubic feet. In this case the cells are charged every day, the time taken to charge being about three hours. The previous cost of lighting by gas and oil was £100, the cost of electric light £120 per annum, including interest and depreciation.

2. *Steam Plant.*—In this case the motive power is a 9 H.P. Paxman horizontal engine with a tubular locomotive boiler. The total number of lights is 150. Fuel used is best steam coal costing 22s. per ton, and the annual consumption is 30 tons. The accumulators are of the E.P.S. type, and are charged every day except Sundays, the average charging time being 5 hours. The maintenance of the cells is about £20 per annum. This plant was erected in 1891. The engine is also used for running saw bench, chaff cutters, corn grinder and corn crusher, the total working cost being about £140 per annum.

In another case for 120 lights installed, the annual average cost works out to £24 per annum, the engine running about two hours each day. This figure does not include wages.

3. *Oil Engine Plant.*—In the following case power is obtained from a 6½ B.H.P. Crossley "Otto" oil engine, running at 200 revolutions per minute. The total number of lamps installed is 104 incandescent and two arcs. The engine house is situated at a distance of about 100 yards from the house, and the accumulators are placed in an attic at the top of the house. The engine also works a pump for supplying water to a tank at the top of the house. This plant has only been erected just one year, but during that time the cells have not been touched, except to refill with acid, and the total working cost has been the oil consumed in the engine, which has been less than 1 pint per H.P. hour, lubricating oil and sulphuric acid.

In another instance of a petroleum engine plant, taken from an account which appeared in the Electrical Review of December last, two Priestman engines of 11 H.P. each are used. These were specially designed with extra massive parts and bearings to be capable of running for lengthened periods without stopping. The wiring is arranged for 293 lamps, or about 500 8-C.P. lamps. The accumulator consists of 60 19-plate cells; these supply current for lighting in the early morning, and for Sunday night only, the rest being done by direct running. With oil delivered at 6d. per gallon, the cost per unit used is about 4¼d., including wages, but the engines do not run at full power. A trial run with one engine fully loaded worked out to 3¼d. per unit generated. In this instance, it was deemed advisable to use oil instead of steam, on account of the distance from the station and the high cost of fuel delivered on the premises. There is also a small stream, but as the power from this is only 3 H.P., no use could be made of it.

4. *Water-Power.*—An instance of a large water-power installation is that erected for the Duke of Devonshire at Chatsworth. The power is here obtained from a lake situated about 400 feet above the level of the house. This is used to drive four turbines giving over 150 H.P. The number of lamps installed being 850. Falls, however, of this description are not often met with in this country.

In another instance, water-power is obtained from a river about ½ mile from the house, with a fall of 14 feet. This is used to drive a Hercules turbine, belted to two 60 amperes 150-volt Goolden generators. The maximum power obtainable from the stream is 50 H.P. There are 110 Epstein cells. The wiring is for 300 lamps, of which most are of 16 C.P. The accumulator is in a building attached to the house, and is charged every day for an average of about three hours. It will be noticed that in this case there are 110 cells, the object of this being that they are charged in series and discharged in parallel. The mains are laid underground.

Before leaving the subject of lighting, it should be remarked that where the electric light replaces oil lamps and candles, the light obtained is usually about eight times as much as previously, for where candles are used in bed-rooms, writing tables, and such like, each candle is generally replaced by an 8-C.P. lamp at least. This, of conrse, assumes that an 8-C.P. lamp gives eight times as much light as the ordinary candle. If, then, we were to instal plants for the same light as obtained from lamps and candles, we should find a great economy by using the electric light.

Motors, &c.—A plant once installed may be advantageously extended to farm and other purposes during the daytime. It is usually preferable, however, to have a separate machine for this part of the

work, but if the work to be done merely consists of pumping water and sawing wood, the same plant can be easily used. Figures as to the cost of this are not easy to obtain, but winnowing machines, corn grinders, laundry mangles, and such like, can be easily run by motors of less than ¼ H.P., and when the rapidity with which the work is done is considered, there can be no doubt as to the saving both in time and labour.

Heating.—Again, in the house the current may be used for heating and cooking purposes.

Though it does not seem probable that the electric cooking range will, in the immediate future, at any rate, entirely replace the kitchen fire, there are innumerable uses to which electric heating may be put, not only with increased comfort, but also, in my opinion, with decided economy. Among other things, I may mention the enormous number of small spirit lamps which are to be found about every house, and which, though perhaps only lit for a few minutes, have to be filled every day owing to evaporation. It is impossible here to enter into any more of the numerous uses of electric heating which will readily suggest themselves.

In conclusion, my thanks are due to Messrs. Drake & Gorham, Messrs. Priestman Bros., Messrs. Crossley Bros., and E.P.S. Company, for information which they have kindly given me on the subject, and to Mr. Kenelm Edgcumbe, for the valuable assistance which he has given me in the preparation of this paper.

MULTIPHASE INDUCTION MOTORS.

By A. C. EBORALL, A.I.E.E.

(*Continued from page* 439.)

2.—The Construction of Induction Motors.

The general construction of multiphase induction motors is practically the same, whether they are designed to be operated with two or three currents. The stator differs only in the winding, and the rotor is identical in the two cases, assuming fixed conditions of supply and running.

Before considering the construction of induction motors in detail, it may be perhaps as well if the general points to be aimed at in their electrical design are briefly enumerated.

Firstly, a very essential point is that both stator and rotor should be quite smooth all round—polar projections on either must be avoided. If this is not attended to, there is (especially at starting) a tendency for the two fields to cog into one another, and as a consequence the effective starting of the motor under load is rendered nearly impossible.

Secondly, the air-gap must be only just enough to permit the rotor to run freely without danger of touching. As the no load current and power factor at all loads depend mainly on the size of the air-gap, it is clear that it must be as small as possible. Further, the larger the air-gap, the greater the leakage at starting, and hence the starting torque will be less, and the current taken greater.

Thirdly, if the induced rotor currents are not confined to proper paths, so that they may be always properly contributing to the driving forces, there will be false eddy currents set up in the rotor conductors which will waste power by heating, and which may even under certain circumstances exert a torque in the opposite direction to that of the main field.

Lastly, the arrangement of the stator winding and iron parts must be such that the leakage field is a minimum, otherwise there may be

Fig. 10c.

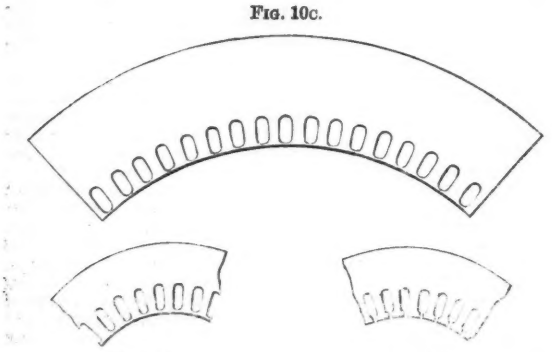


Fig. 10a. Fig. 10b.

eddy currents in the motor frame, and even in the stator conductors themselves, causing loss of energy; furthermore, if there be much leakage from any cause, the motor is sure to start badly, its power factor will be low, and it will have a large drop in speed if overloaded.

The methods adopted in practice to satisfy these conditions will now be considered.

The Stator.—The stator of modern motors is always built up of lightly insulated soft iron core discs; these, as shown in fig. 10 (c. a. b.), being either slotted, or pierced with rectangular holes for the reception of the windings. Whichever construction is used, the apertures in the iron must be punched very near the inner edge, or else there may be considerable leakage across the small iron bridges or air gap. In practice the distance of the hole from the internal periphery of the stator is rarely more than 3 millimetres in the largest motors, and is a mere shred of iron in the small ones. If the stator be of large size, the core discs are not punched out in one piece, but in sections, as shown in fig. 10c, these sections being afterwards bolted up together, the joints in one layer being covered up by the next.

The depth of the hole or slot varies in practice from 1½ times to 3 times its width; it should be as small as possible, as leakage increases with the depth of winding. The distance between each hole or slot is a little more than the width, there being preferably many small slots or holes rather than fewer large ones, as these would tend to destroy the evenness of the field, and might cause heating of the rotor.

The advantages of thus imbedding the windings (first introduced by Mr. C. E. L. Brown) are several. For example, the weight output is increased, the magnetic resistance is reduced to a minimum (and hence a small magnetising current and larger power factor), and eddy currents in the stator windings are prevented. Further, if the rotor windings are also imbedded, as in practice is the case, the air gap need only be large enough to give the necessary

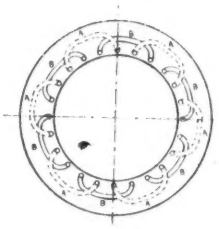


Fig. 11.

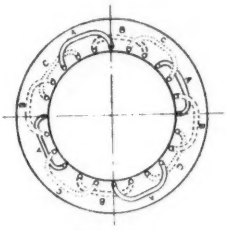


Fig. 12.

mechanical clearance, the strain comes on the iron, not on the windings, and both rotor and stator are quite smooth all round.

As to which is the better, the hole or slot, probably taking them all round there is not much to choose between them. The pole produced by hole winding is more even than that produced by slots, but owing to the absence of the small iron bridges, there is probably less leakage with the latter.

The next thing to consider is the winding. The speed of the motor and frequency of supply being fixed, the number of poles is at once determined by the rule already given. They may be produced by either a ring or drum winding, but it may be taken that the latter winding is the best, as since its introduction by Messrs. Brown, Boveri & Co. in the early days of multiphase motors, it seems to have been adopted by all the leading makers of multiphase machinery—at any rate, for large work. Ring winding has several disadvantages—its magnetic leakage is greater—it requires more wire for the same effect—and further, ring winding precludes the use of an iron case for holding up the stator core discs, on account of the leakage that would be produced through it. The bad effect of leakage on the starting and power factor of an induction motor have already been pointed out.

Figs. 11 and 12 show diagrammatically the method of drum winding introduced by the above firm. Fig. 11 is a six-pole winding for a two-phase motor. The two phases are marked A and B respectively.

In practice each coil of one phase is wound quite straight, its shape being rectangular, while the coils of the other phase are bent up and over the coils of the first phase.

Fig. 12 shows a four-pole stator winding for a three-phase motor, the phases being marked A, B, and C. It will be seen that the coils of each phase are alternately straight and bent.

By the use of such a drum winding, the winding space is utilised to the best advantage, the insulating of the coils is rendered both simple and effective, a coil can be very easily rewound should the necessity arise, and the chance of one phase making contact with any other is minimised.

In the case of a two-phase motor, each circuit is, as a rule, quite distinct, the coils of one phase being wound in between the coils of the second phase, as indicated in Fig. 11. It is, however, perfectly practical (but on the whole not desirable) to work a two-phase system with the two phases interconnected, a single return wire of 1·4 times the section taking the place of the other two. A motor running from such a circuit would, in that case, have its circuits connected together, the junction of the two phases in the motor being joined to the line wire of larger section.

With three-phase motors, the stator may be wound either as "star" or "mesh," or a combination of both, as previously pointed out. The weight of copper required for a "star" winding is about the same as that required for a "mesh" winding, the choice of one or the other depending mostly on the voltage of supply and the size of the motor. Thus for large low voltage motors, the mesh is most frequently used, while for high voltages the star is better, as the strain on the insulation of any one set of coils is less, owing to the line voltage being shared by two sets of coils, and being 1·73 times the voltage of any one set, as pointed out before.

The Rotor.—Rotors for induction motors may be of two kinds, namely, a simple short-circuited winding, or a regular winding whose ends are joined to slip rings on the shaft, and between which may be inserted resistances used as a rule only during the starting of the motor, and whose function will be discussed later.

If the rotor is of the first form, it is built up of core-discs of the shape shown in fig. 13A, each stamping being lightly insulated from its neighbour, and the two end plates being made considerably stouter than the rest for the sake of stiffening the rotor. If the latter be above a certain diameter, three or more bolts are passed through from end to end and parallel to the shaft for the same purpose. Through the holes in the core discs (which are punched as closely as possible to

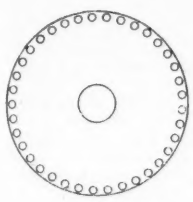


Fig. 13A.

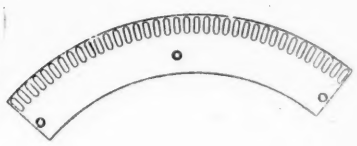


Fig. 13B.

the periphery) copper bars are passed through, the bars being insulated by paper or other material from the iron. The copper bars are short-circuited at each end by copper rings, the section of these rings, for a reason presently to be explained, being considerably less than the total section of the bars.

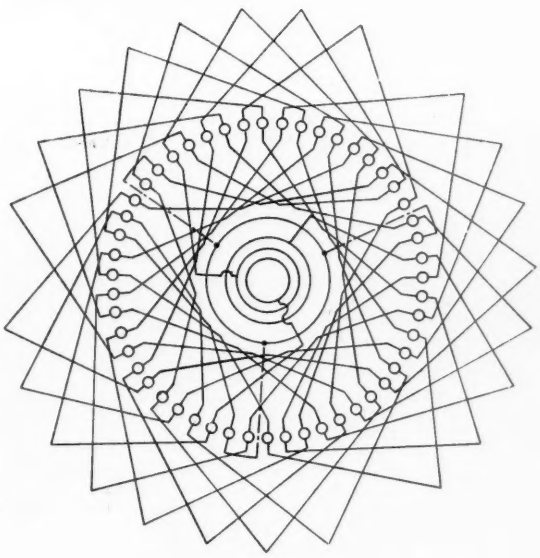


Fig. 14.

The reason for insulating the rotor bars at all is simply to fulfil one of the conditions previously enumerated as to confining the rotor currents to proper paths. The reason for using rings for short-circuiting the bars is partly because they offer a good cooling surface, and partly because by their use overwrapping at the ends and the use of connectors is avoided, the whole forming a sound mechanical job.

The number of holes in the rotor is never the same as the number of holes or slots in the stator, and it is better if the number of rotor bars and stator holes do not have a common factor, otherwise the motor may start badly, owing to the tendency of the fields to cog into one another.

If the rotor has to be of the second form mentioned above, with its windings connected to slip rings, its construction is somewhat different. As such a rotor is generally of large size, the core discs are built up in sections, as in fig. 13B, and owing to the fact that the centre iron part of large rotors is inactive, these

Fig. 16B.

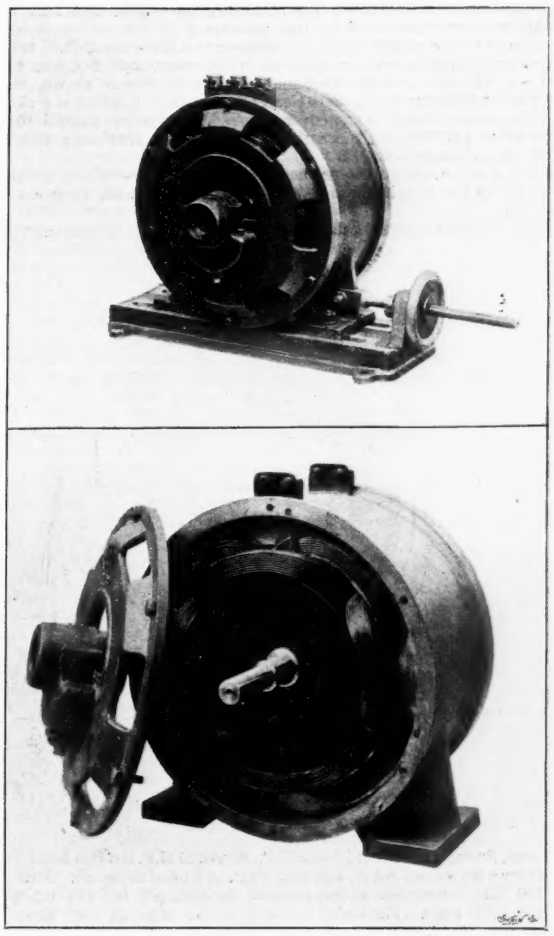


Fig. 16A.

sections are built up either on a spider, or else on the rim of a fly-wheel, according to the size of the motor.

The number of holes or tunnels is determined by reference to those in the stator, they being always more numerous than those in the latter, and an uneven multiple of them when possible. It follows from this that the rotor holes or tunnels will be longer and narrower than those in the stator.

In regard to the winding, it should have as small a self-induction as possible, and is preferably of copper strip placed edgeways in the tunnels. A wave winding, connected star fashion, is invariably used, the common junction being made on the iron work of the rotor. Apart from the question of self-induction, it is generally not advisable

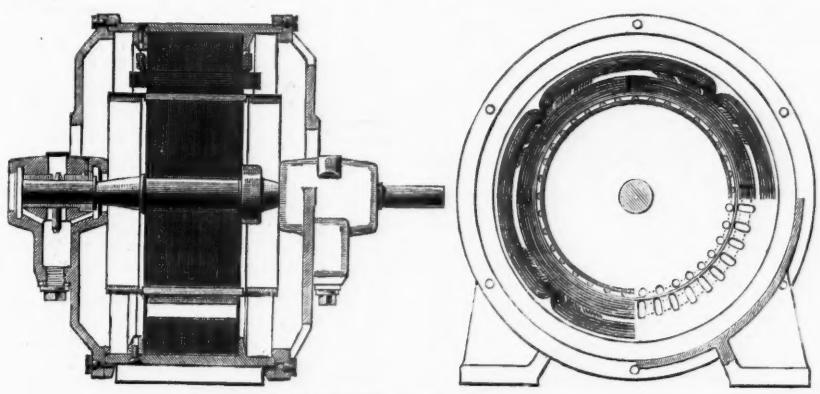


Fig. 15.—6 H.P. Two-Phase Induction Motor.

to use more than one conductor per hole, because (to avoid dead points in starting) the number of rotor holes is frequently uneven, which results in very irregular windings. An example of an unsymmetrical rotor winding of this character is shown in fig. 14, which gives the winding scheme for a four-pole rotor of American design.

By the courtesy of Mr. C. E. L. Brown, the author is enabled to illustrate each of the preceding varieties of motor by the scale drawings shown in figs. 15 and 17, and the photographs in figs. 16 and 18. Owing to the unrivalled experience which his firm has had in the design and construction of multiphase plant, they may be taken as representative of the best practice of to-day.

The drawing shown in fig. 15 represents a four-pole 6 H.P. two-phase motor, with simple short circuited rotor, and designed for 40 ~. The electrical and mechanical details are clearly shown, but the stator winding is still more clearly seen in fig. 16A, which is a view of the same motor with one cover removed. It will be noticed that the method of winding is exactly the same as that previously shown diagrammatically in fig. 11.

Fig. 16B is a similar motor, but wound for a three-phase circuit, and shows the simple form of belt-tightener used with these small motors.

These figures represent standard types of induction motors built by Messrs. Brown up to about 12—15 H.P. Above 15 H.P. the firm builds its motors with wound rotors and slip rings, as shown in fig. 17. This is a 100 H.P. three-phase motor, and can be arranged for any tension up to 5,000 volts. The stator winding is the same as that already shown in fig. 12.

(*To be continued.*)

THE TRANSMISSION OF POWER TO LONG DISTANCES BY ALTERNATING CURRENTS OF ELECTRICITY.*

By W. B. ESSON, M.Inst.C.E., M.I.E.E., &c.

This is not the first occasion on which your attention has been directed to the subject of the transmission of power by electricity. Mr. Gisbert Kapp in 1891 delivered an excellent course of Cantor lectures, which dealt very fully with what had been done up till that date, but from then till now the progress in this particular department of applied electricity has been so great, that the value of the 1891 lectures has become chiefly historical. It would be quite impossible for me, in view of the enormous strides made in recent times, to deal adequately in a single paper with electric transmission of power generally, so as implied by the title I propose to limit my remarks at present to transmission by alternating currents and to long distances. In so doing I cut out a vast field of application, but I can in consequence deal more fully with the branch I have chosen, and it will be remembered that transmission by direct currents in its most important application, viz., to street railways, was dealt with here by Mr. Parshall only a year ago.

Starting then where Mr. Kapp left off in 1891, you will perhaps remember that in the last of his Cantor lectures he apologised for taking up the time of the audience with the very interesting exposition he gave of the theory of polyphase motors. He described his observations as leaving "the safe ground of solid facts and engineering practice to enter into the domain of speculation," declaring, however, his conviction that some form of alternate current working would prove the ultimate solution of the problem how to transmit power—possibly over all distances—but certainly over very long distances. Well, that prediction has been marvellously fulfilled, for all long distance transmission work is done by alternating currents and nearly all by polyphase motors.

The alternating current systems at present employed for transmission work are enumerated in the following classification of generators, conductors, and motors.

	Generators.	Line.	Motors.
1.	Single phase.	Two wires.	Synchronous or non-synchronous.
2.	Two-phase.	Four wires or three wires.	Synchronous or non-synchronous.
3.	Three-phase.	Three wires or four wires.	Synchronous or non-synchronous.
4.	Mono-cyclic.	Three wires.	Non-synchronous.

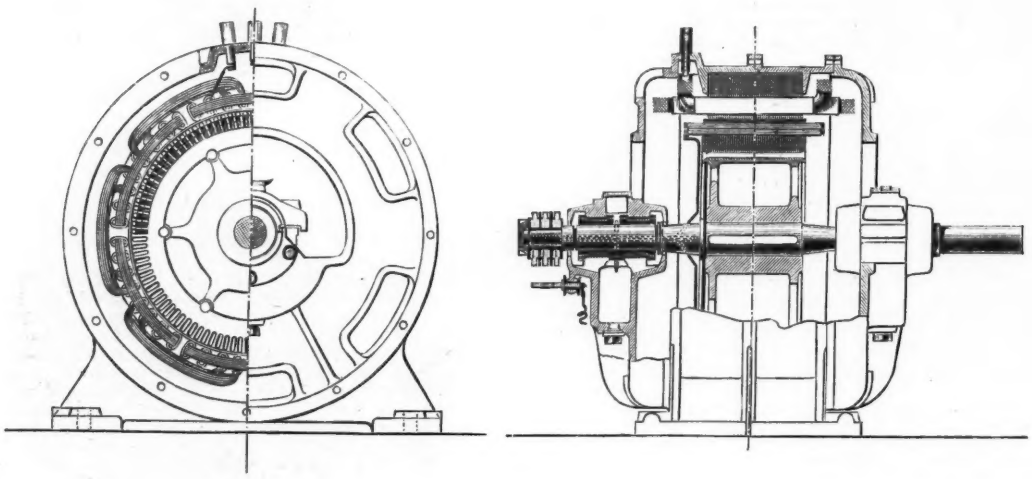


Fig. 17.

It is impossible to discuss either of these three principal factors in power transmission without some reference to the others, but it will be nevertheless convenient to divide my remarks into the headings given, and to keep to the order indicated.

I.—Generators.

It will be seen that the generators are single phase, two-phase and three-phase, corresponding to the three well-known systems of power transmission. As we shall see later, the mono-cyclic system, for which the fourth generator on the list is required, is an ingenious combination of single phase and three-phase systems. The single phase machine, as its name implies, generates one alternating current only. The two-phase machine generates two distinct alternating currents, displaced relatively to each other by a quarter of a cycle. It will be seen that when one of the currents has its maximum value, the other has always a zero value. The three-phase machine produces three distinct alternating currents, displaced relatively to each other by one-third of a cycle.

Every alternating current lighting station in the kingdom is equipped with single phase generators—you are doubtless familiar with several types—and the high pressure distribution is effected, of course, on a two-wire system. In two-phase working the respective circuits may be kept quite distinct throughout, or one termination of both circuits may have a common junction, there being then three terminals for the line. If the circuits are independent, four-line wires are employed; if joined to three terminals, only three wires are used, one rather larger than the other two, being common to both circuits.

In three-phase working the algebraical sum of the currents in the three circuits, provided perfect balance is maintained throughout, is *nought*, accordingly in a return wire, common to the three circuits, no current would flow. On this account it is usual to dispense with a return conductor for the transmission, all three circuits having a common junction at each end of the line, and three wires only being used. As we shall see later, a fourth wire for the distributive part gives advantages which are well worth consideration.

In selecting generators for power work, several very important cosiderations have to be kept in mind. In the first place it is essential that the machines be of first-class construction, from a mechanical point of view, as alternators employed for power transmission have, so far as my experience goes, to work under conditions much more trying than have machines for lighting. From advices to hand

* Paper read before the Society of Arts on Wednesday, March 24th, 1897. From the Society of Arts *Journal*.

while I write,* for example, I learn that the two-phase generators at the Sheba mines ran all through September, night and day, from the 1st to the 30th, without once stopping. Such runs try machines severely; but not only may transmission alternators have to work continuously, but they are generally fully loaded. This further tests their staying qualities, making it imperative that nothing but designs of the soundest engineering character should, for this kind of work, be thought of.

It is essential that the armature coils be not subjected to stresses which tend to alter their shape, or to destroy, in time, the insulating materials. Such substance as mica, micanite, stabilit, presspahn, &c., are quite unfitted to transmit force, accordingly all alternators for power work have their armature coils embedded in a laminated iron core. In some cases the wire forming the coils is wound through holes in the core plates, while in others the coils, independently formed, are placed in slots punched perpendicularly to the surface of the core; but there are no conductors in the gap between the field magnet and armature core. In the case of the coils in slots, these are machine wound on a former or mandril, and thoroughly bound together with several wrappings of rubber-impregnated tape, or other suitable insulating material, before being put in place. Generally, in American machines, the armature is the rotating part, while in European machines it is the fixed part. In the rotating armatures the machine-wound coils are firmly wedged into radial slots on the surface of the core. Other things being equal, a stationary armature is to be preferred, because the armature is the high pressure part of the generator, and when stationary it can easily be protected, so that accidental contact with the circuit is absolutely impossible.

That the efficiency of the generator or ratio of electrical output to mechanical input of power should be as high as possible goes without saying, but it is, perhaps, of still more importance that the armature reaction should be very small. Armature reaction is manifested by the drop of pressure from no load to full load, and in large alternators for lighting work a drop of from 10 to 15 per cent. is not unusual under conditions of constant excitation and speed, nor does this cause any inconvenience. But for running non-synchronous motor circuits, such a generator would be quite unsuitable. The motors act like so many choking coils, the result being that the same generator, which has on an inductionless lamp load a drop of no more than from 4 to 5 per cent., will have, when working on a motor load, a drop from four to five times as great. It is very important, therefore, that any alternator intended to be used for power transmission shall have a small drop tested on an inductionless load, seeing that on the power circuits this drop is greatly magnified. High efficiency does not necessarily mean small armature reaction, but since the satisfactory working of the plant greatly depends on securing the latter and avoiding difficulties of regulation which would otherwise occur, it will be obvious that a certain amount of power may be sometimes wisely sacrificed to attain this desirable end.

Another important point, of course, is the size of the generator. In the preceding paragraph I have spoken of polyphase motors acting as choking coils, and an inductive load, as you are no doubt aware, not only causes a large drop of pressure at the generators, but also makes the current lag behind the E.M.F. As their phases are not co-incident, the product of virtual amperes and virtual volts does not give the power in watts going into the circuit; to get this latter the product has to be multiplied by a co-efficient depending on the difference of phase. This co-efficient is called the power factor, and is the fraction which expresses the cosine of the angle of lag; it is the ratio of the *real* to the *apparent* watts given to the circuit. As we shall presently see, the power factor has a different value for different sized motors, and lies somewhere between ·65 and ·85. If two-thirds of the power given by the generator were taken up by non-synchronous motors, the power factor would probably be about ·8 for the whole circuit; but if the power were nearly all taken up by motors large and small mixed, it would be less than this; certainly it would not be safe to take it as exceeding ·75 at the outside. Now what does this signify? It means that the generator must be at least one-third larger than it would require to be if the phases of current and E.M.F. were coincident. Because the power factor is ·75, the machine has to supply one-third more current to the circuit; in other words, if we wish to give 100 electrical H.P. to the line, we must provide a generator capable of giving 100 kilowatts on an induction load. It also means that our lines must be one-third heavier because of the extra current to be transmitted, and our transformers, if we have any must follow suit, and be installed of a capacity equal to 1 kilowatt for every horse-power. It will be seen that an increased power factor would result in a reduced outlay for the plant all round, but of this more anon. At present I need only say that it is most desirable to provide everywhere ample margin, and plant should be provided at the rate of not less than a kilowatt per horse-power transmitted as stated above. Though some motors may have a higher power factor than ·75, many have less, and it is well always to be on the safe side.

Now comes the question of the number of reversals of the current per second, regarding which there has been a good deal of discussion. British engineers are accustomed to talk of the number of complete cycles per second, meaning by *cycle* a current first in one direction and then in the other, as indicated by the complete wave. Instead of repeating "complete cycles per second" every time, however, they use the word *frequency*, so that a "frequency of 50" means that the current is reversed 100 times per second, or that there are 50 complete cycles per second. In the working of synchronous motors the frequency question is of comparatively minor importance, but with regard to non-synchronous motors which are now almost universally employed for power work, it is of the greatest importance. There is no particular frequency, the best under all circumstances, but it must be remarked at the outset that whatever the views held by lighting engineers, all who have had experience of power transmission agree as to the desirability of a low frequency; so far as power *per se* is concerned, the lower the better. You are doubtless aware that in the States the first alternating current plants were run at a very high frequency. The ordinary thing was from 125 to 132, a figure which was very suitable for scattered distribution and small transformers. With the development of alternating current motors, however, the frequency for the standard designs of alternators has gone down to 60, while for machines which have to supply currents for power only, the figure has been reduced to about 30. In the case of Niagara, and some other large plants, it is 25. In Europe, the frequency for power transmission work ranges from 40 to 60, and the mean of these figures, 50, is about the lowest that can be adopted consistent with obtaining satisfactory results on the lighting circuits, which are in a greater or less degree generally combined with power transmission. At 50, the fluttering of arc lamps, when they are enclosed in opalescent globes, is inappreciable at a distance of a few yards.

It will be seen, then, that engineers have had to remodel all their designs for the purpose of power transmission, consequent on the high frequency permissible, nay, advantageous, for lighting, being altogether unsuitable for circuits running non-synchronous motors. Anything above 60 is to be viewed with distrust and we would go down to half this, or even below, if we could then, in a satisfactory manner operate lighting circuits without introducing complications too costly to be justifiable. When we go above 60 we begin to get into trouble with generators, line, and motors all round. This is not the place to go into the many practical and theoretical considerations which have led to the universal adoption of the low frequency; suffice it to say that only the strongest reasons induced one engineer after another to alter his designs to suit power transmission work. Experienced men are all agreed as to advantages of low frequency, and it is a matter for congratulation that there is specified for the electric lighting works now in progress a frequency only about half of what was usual some time ago. As a consequence, the circuits are rendered much more suitable for the working of motors.

Another thing of some importance is the form of the E.M.F. curve of the generator. Shall it be flat-topped, or resemble the teeth of a saw, or be like any of the irregular figures shown by Dr. Fleming in his recent lectures on transformers, or shall it be a sine curve pure and simple? Well, the opinion universal amongst engineers having to do with power transmission is that alternators giving a sine curve for the E.M.Fs. are in all respects the most suitable. It has been shown, as you probably know, that so far as hysteresis loss in transformers is concerned, the saw tooth curve is best, but in transmission work there are many other things to be considered, and experience has shown what one might almost have arrived at by intuition namely, that for smooth running a simple harmonic curve is best of all.

But to return to construction. The first polyphase generators consisted of a couple of ordinary alternators having their shafts rigidly coupled together so that the two currents produced by them were displaced by a quarter period. This was costly, inasmuch as two small machines are more expensive than one large one, and the next step was to combine the two machines in one, thus producing a two-phase generator proper. The most obvious way of doing this, so far as machines with rotating magnets were concerned, was to displace one half of the fixed armature coils relatively to the other half, so that the currents of different phases were generated each by a separate half of the fixed portion of the machine, the magnets being common to both. The generators constructed by Messrs. Johnson and Phillips for the Sheba Mine plant were of this type. The armature consisted of a number of iron sectors, which were mounted in a cast-iron shell made in two halves. A machine-wound coil was fixed on each sector. The seven coils in the top half generates one current, the seven in the bottom half the other, with a phase difference between them of 90°. Each current has a virtual difference of potential of 3,300 volts, so that every coil is responsible for about 470 volts.

Generators of the above type, though capable of doing excellent work, are no better as regards armature reaction than are single-phase machines. Each semicircle of coils reacts separately on the magnet to weaken the field, and produce other effects which can well be dispensed with, while obviously it would be of advantage to usefully employ some of the space on the armature presently unoccupied by windings. As I have already said, the drop in pressure between no load and full load depends primarily on armature reaction; it is desirable, therefore, that any way of arranging the coils be adopted by which the reaction can be reduced. When we want to keep the reaction low in single-phase generators, we make the number of convolutions on the armature coils as few as possible, the field as strong as possible, and the air space between the armature core and magnet tips fairly large. In polyphase generators we can do all these things, and one thing more which greatly helps us, that is, mix the coils of the several phases. This latter constitutes an important point of difference between the machines just described and those now constructed by the same firm. One form of armature with mixed coils consists of a number of laminated iron sectors mounted in a cast-iron shell as before, but in each sector are embedded two machine-wound coils displaced relatively to each other by a quarter phase. The sectors are built up independently by laying charcoal iron plates one on the top of the other until the necessary depth is obtained, the corners of each plate being bent out of the way to get it over the coils, and straightened back again when in position, and before the next plate is put on. It will be seen that instead of there being semi-circles of coils all of one phase reacting upon the magnets, what effect there may be now is due to the re-

* November 9th.

sultant of the two currents of different phases flowing in the inter mixed coils. The result is, that the reaction is greatly diminished, also that whereas the machine first described could only give for similar carcase dimensions, as a two-phaser, the same output it gave as a single-phaser, from the new machine with the intermixed coils there can be obtained, the carcase remaining the same 25 per cent. more output.

Armatures with their coils wound through holes in the core plates have also the windings of the different phases intermixed. In such cases a micanite tube is first inserted into the hole and the wire is wound through it. Another armature is that in which machine-wound coils are laid into slots punched on the interior surface of the core. It is to be observed that both in the case of the armature formed of sectors and the hole-wound armature the core surface presented to the field magnets is smooth; in the case of the armature with the coils laid in slots however, the core surface is to some extent discontinuous.

Other things being equal, it is of advantage to have a construction such that the armature coils can be readily replaced by spares in case of an accident. In Johnson & Phillips's two-phase generators just described, each sector being independent, it can be replaced in a few minutes, and that without disturbing any of the adjacent sectors or making any other preliminary preparations, such as lifting the top half of the armature, racking the halves of the armature apart, or lifting the field magnet. In the machine with the armature coils wedged into slots the coils can be removed, but not without some trouble, and then either the halves of the armature must be racked open, or the field magnet lifted. With the hole winding, independence of the coils cannot be readily secured, and in the case of a burn-out, the machine has to be shut down while the repairs are effected.

Three-phase generators, in which the coils belonging to the different phases are intermixed, may have hole windings, but armatures for three phases can also be built up of movable sectors, each having one coil. When so constructed, each third coil counted round the armature belongs to the same phase, and the coils are therefore coupled in three sets, so that if they are numbered 1, 2, 3; 1, 2, 3; 1, 2, 3; all round, all the 1's will be in one set, all the 2's in the other, and the 3's in the third. The armature reaction, in a machine of this kind, is greater than with intermixed coils, but it is certainly not so great as in the case of a single phase, or of the two-phase machine, with the sectors in separate semi-circles.

Having said so much regarding the armature, we may shortly consider the field. The magnet of the Sheba generators consists of a star-shaped steel casting in two halves, excited by a single coil wound on a central boss, from which project N poles on one side, and S poles on the other. These polar projections are bent round and interlaced so as to form a circle of N and S poles, alternately running with a clearance of ⅛rd of an inch or so between the tips and the armature core. This form of field magnet was employed originally by Mr. Brown for the well-known Frankfort-Lauffen transmission, and has the advantage of requiring a very small amount of copper for excitement, as compared with other forms. It has, however, the disadvantage of a comparatively large stray field, with the exciting coil at some distance from its work, and the consequence is that when loaded on motors, a large proportion of the induced field never enters the armature, a considerable drop of pressure with the load resulting. I have just said that to keep the armature reaction small, the field must be strong, and as this strength is wanted between the field poles and the armature, the importance of getting the magnetising force as close as possible to the magnet tips will be obvious. On this account the multiple coil magnet has been more largely used for power work than the single coil magnet, as the coils of the former can be brought close up to their work. If the single coil magnet is employed, the designer must bear these points in mind, also he must keep the masses of iron in the poles as small as possible. The single coil has not yet been used for generators with rotating armatures.

Whether the magnets require to be laminated depends upon the construction of the armature. With an armature core presenting a smooth surface to the magnet, the air gap being uniform, and things arranged so that the magnetic reluctance is for all positions of the magnet the same, lamination of the field is not very necessary. The armature built up of sectors as already described, complies with these conditions, as well as armatures having hole winding. But for armatures having open slots to receive the coils, lamination of the magnet is necessary, if not throughout, at least the tips must be laminated. In the best known American machines the magnets are laminated throughout; they consist of sheet iron stampings bolted together.

Generators are designed to give from 2,000 to 3,000 volts for small outputs, and from 3,000 to 5,000 volts for large sizes. In very large machines a pressure of 10,000 volts could no doubt be managed, but then it would be just a question as to whether it would not pay better to generate at low pressure, and raise the voltage for the line by means of step-up transformers. At present the practice is not to exceed in the generators 5,000 to 6,000 volts, and the experiment of running at high pressure for power work has yet to be made.

The mono-cyclic generator is peculiar to the "mono-cyclic" system, which deserves remark as constituting a means of preserving the simplicity of single phase distribution for lighting, while securing the advantages of a three-phase system as regards the starting of motors, and to some extent their running. I regret that the time at my disposal does not permit me to describe this very interesting system. It has made, I understand, some headway in the States, though I do not know that there is much scope for it in this country, or that it will be employed for general transmission work to any great extent.

(To be continued.)

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS.

NEW PATENTS.—1897.

[*Compiled expressly for this journal by* W. P. Thompson & Co., *Electrical Patent Agents, 322, High Holborn, London, W.C., to whom all inquiries should be addressed.*]

6,720. "A new or improved electrical apparatus for perforating designs." P. E. Glorget. Dated March 15th. (*Complete.*)

6,743. "The Mayes electric accumulator plate." A. H. Mayes. Dated March 15th. (*Complete.*)

6,751. "Improvements in electric bells." B. Dukes. (J. G. Mehne, Germany.) Dated March 15th.

6,773. "Improvements in connections of telephonic and telegraphic instruments to conducting lines." L. Maiche. Dated March 15th.

6,774. "Method and appliances for brazing or soldering by electricity." W. C. Johnson. Dated March 15th.

6,778. "Improvements in electric current conducting apparatus for electric railways with underground feed." C. F. P. Stendebach and O. H. Linker. Dated March 15th. (*Complete.*)

6,782. "Improvements in insulated electric conductors." H. Edmunds. Dated March 15th.

6,818. "An improved storage batttery." J. Entwisle. (C. T Barret, United States.) Dated March 16th. (*Complete.*)

6,820. "Improvements in and relating to arc lamps." D. Neale. Dated March 16th.

6,825. Improvements in connection with the supply of current to and governing arc lamps." F. M. Lewis. Dated March 16th.

6,868. "Improvements in electric arc lamps." T. E. Adams. Dated March 16th. (*Complete.*)

6,929. "An improved diaphragm for separating the gases in electrolysis of sodium chloride and other salts and other improvements." F. Taylor, A. Cooke and B. W. D. Montgomery. Dated March 17th.

6,962. "Certain improvements in electro-plating apparatus." J. Guise. Dated March 17th.

7,005. "An improved system of current supply for electric railways." A. Petzenburger. Dated March 17th. (*Complete.*)

7,012. "Improvements in supplying electrical energy to electrically propelled aerial machines and balloons." R. Diesel. Dated March 17th. (*Complete.*)

7,020. "Improvements in or relating to the conversion of electric currents." F. C. Parkhurst. Dated March 17th.

7,024. "Improvements in electric welding." G. W. de Tunzelmann and C. W. Baker. Dated March 17th.

7,027. "Improvements in and relating to secondary batteries or accumulators and the manufacture thereof." A. J. Marquand. Dated March 17th.

7,030. "Improvements in electrical signalling apparatus." G. K. B. Elphinstone. Dated March 17th.

7,034. "An improved electrical terminal." G. H. Congdon. Dated March 18th.

7,096. "Improved method of regulating the speed of series electric motors." H. F. Parshall. Dated March 18th. (*Complete.*)

7,113. "Improvements in primary batteries." F. H. Perry. Dated March 18th.

7,189. "Improved current supply for electrical railways." M. Ott, jun., and A. Silbermann. Dated March 19th. (*Complete.*)

7,212. "An improved rheostatic apparatus particularly applicable to the starting of electromotors." G. E. Dixon. Dated March 19th.

7,235. "Improvements in switching apparatus, more especially adapted for use with electric motors." H. Edmunds. Dated March 19th.

7,272. "Improvements in junction boxes for electric cables." J. E. Stewart. Dated March 20th.

7,305. "Improvements in brushes for the commutators of electric dynamos and motors." E. L. Joseph. Dated March 20th. (*Complete.*)

7,314. "Improvements in or relating to accumulator plates or electrodes for secondary batteries." F. E. Everard. Dated March 20th.

7,315. "An electric circuit-hour meter or automatic cut-out." C. O. Bastian and F. M. Staunton. Dated March 20th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Copies of any of these Specifications may be obtained of* Messrs. W. P. Thompson & Co., 322, High Holborn, W.C., *price, post free,* 8½*d.* (*in stamps*).]

1896.

1,237. "Improvements in and relating to electric incandescent lamps." C. J. P. Robertson. Dated January 17th, 1896. Caps are secured to incandescent lamp bulbs without the aid of plaster by means of a ring secured in a groove in the neck of the bulb. The ring is soldered or connected by a bayonet joint to the cap. Various modifications are described. 1 claim.

2,107. "Improvements in telephones." J. Imray. (A communication from La Société Anonyme pour la transmission de la force par l'electricité.) Dated January 29th, 1896. Relates to a system of telephony by means of alternating currents of different frequencies one pair or a greater number of line wires serving for transmitting currents for many sets of telephones. 3 claims.